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Early Paleolithic technology in China and India. (Volumes I and II)

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EARLY PALEOLITHIC TECHNOLOGY IN CHINA AND INDIA

by
Jian Leng

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT OF DISSERTATION

Early Paleolithic Technology in China and India

By

Jian Leng

Doctor of Philosophy in Anthropology

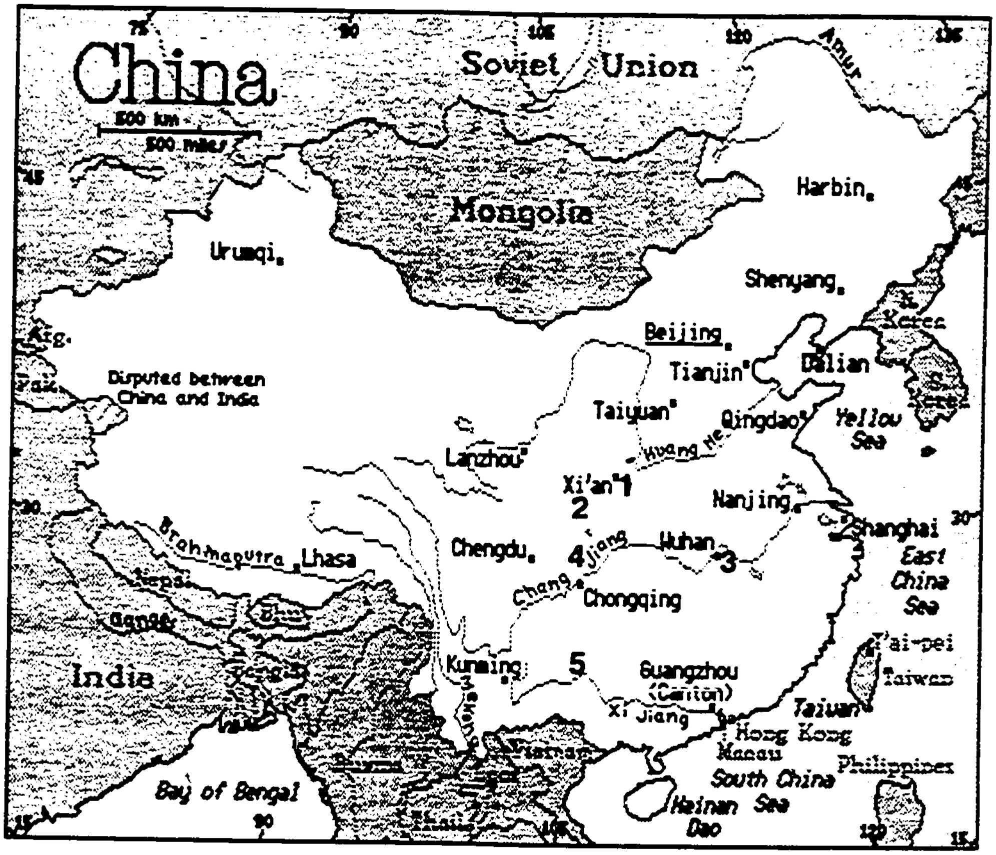
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Professor Patty Jo Watson, Chair

The primary objectives of this project are threefold; first, to assess the thesis that the lack of bifacial lithic technology in Southeast and Eastern Asia during the Lower Paleolithic indicates cultural retardation; second, to reexamine the wide range of variation in the typological composition of lithic assemblages and their technological patterns; third, to locate the sources of local raw materials, using these local raw materials to replicate various typologies and technologies, and to ascertain whether the varying characteristics of these sources significantly affect the nature of Lower Paleolithic tool assemblages. The scope of this project was both geographical and cultural. I worked at five archaeological sites in China (Lantian, Liangshan, Shilongtou, Guanyindong, and Bose), and three in India (Bhimbetka, Durkadi, and Hunsgi). I also investigated the geological features of the Kathmandu valley and reviewed material of an Early Paleolithic site, Kao Pah Nam, in Northern Thailand.

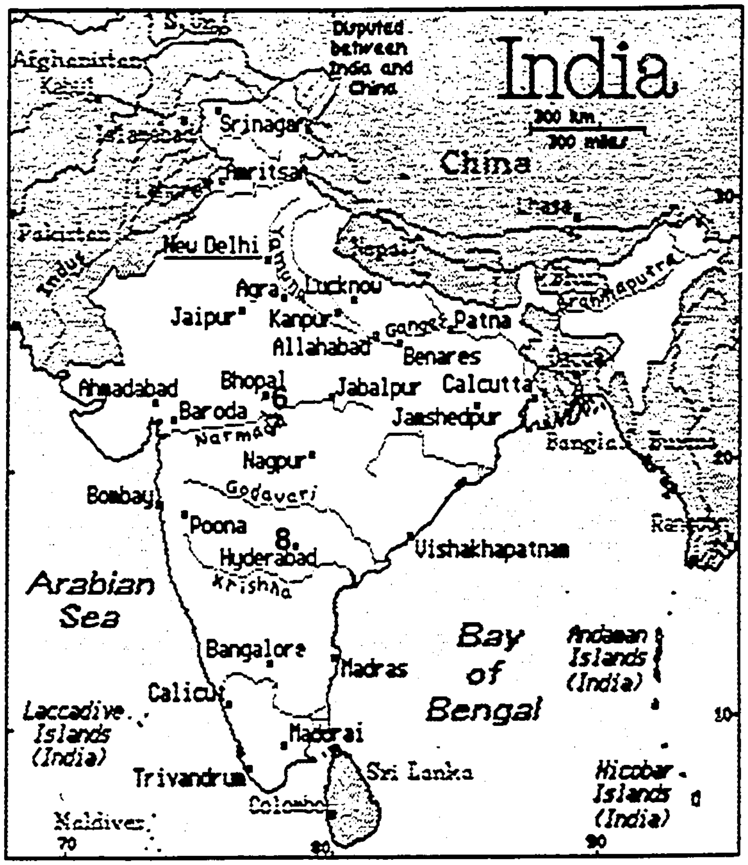
The primary approach was to use local raw materials to replicate archaeological lithic assemblages based upon the supporting archival materials from the excavation. I recorded the size, weight, quality of raw material and distance of sources from the site, and also documented the length, breadth, thickness, weight and number of the flakes in order to evaluate the effect of the raw material on artifact manufacture and artifact use.

The initial understanding provided by this project is based on the large number of new, Early Paleolithic finds in South and East Asia since the 1930s. Most of the sites I worked with were excavated within the last 15 years. There are many variations of typologies and technologies among these recently discovered early stone tool assemblages, so many in fact that once these findings are brought together, as in the present project, one realizes that it is not accurate to speak of cultural retardation in Southeast and Eastern Asia during the Lower Paleolithic. My fieldwork also indicates that geographical features and raw material availability directly affect artifact manufacture, the size and shape of stone tools, and the technology selected.



MAP. Location of the Sites in China

KEY: 1. Lantian 2. Liangshan
3. Shilongtou 4. Guanyindong
5. Bose



MAP. Location of the Sites in India

Key: 6. Bhimbetka 7. Durkadi
8. Hunsgi

Chapter 1 Introduction

1. Development of the Project

In this dissertation I examine the technological and typological characteristics of Paleolithic stone tool assemblages from eight sites distributed through the central and southern part of China and the northern and central part of India. I examined and then replicated the lithic assemblages of these eight sites to identify and define the factors involved in the typological composition of these early Asian assemblages. I focus on the typological characteristics of the tools, examining the relationship between the technology employed in producing them and local environmental circumstances, particularly the raw material available for tool production.

Stone tools are one of the most important primary sources of cultural and behavioral information available for the anthropological study of our Early Pleistocene ancestors. Stone tools first appear in the Lower Paleolithic about 2.4 million years ago in East Africa, and it seems very likely that the development of stone technologies played an important role in the success of the genus *Homo* over the last 2 million years (Toth, 1985). While there are limits to the range and depth of information that can be gleaned from the investigation of early stone artifact assemblages, such information is so crucial to our

understanding of early hominid origins that we must draw out every clue these lithic assemblages may yield. Detailed analysis and interpretation of these archaeological assemblages is especially important when patterns of significant diversity and variability require explanation. Such is the case with the lithic assemblages from the East and Southeast Asian Paleolithic (see J.S. Aigner, 1981 and K.C. Chang, 1977 for recent authoritative summaries of East Asian Pleistocene prehistory).

Studies of Early Paleolithic technology, including analyses of artifact raw material, have been carried out by M. D. Leakey (1971), Hay (1968), Stiles (1974, 1979, 1980, 1991) and Jones (1979) on artifacts from Olduvai Gorge, Tanzania. Toth has strongly emphasized the importance of the raw material when interpreting the technology and other characteristics of lithic materials found at Paleolithic sites (Toth, 1985). The late Glynn Isaac published a number of relevant and very important articles based in his major projects at Olorgesailie, East Turkana, and Peninj, west of Lake Natron in East Africa (1971, 1972, 1976, 1977, 1984, 1986). Following Binford's (1968) emphasis on the relationship between stone tools and adaptation, Isaac insisted that differences in the use of raw materials in artifact manufacture would have to be discovered and explained before any reliable conclusions concerning the cultural tradition or technological expertise of the

producers could be reached. Concern with the varying characteristics of different raw materials has been primarily focused upon Africa and Europe; it has not previously influenced appraisals of the cultural traditions found in Southeast Asia. In my work, I apply the raw material and technology approach to Early Paleolithic collections from Southeast Asia.

By investigating the variability of tool assemblages from the Asian Middle Pleistocene I hope to provide a basis for inferences about human technology during the Middle Pleistocene as well as the means to make meaningful comparisons between early Asian stone tool technology and technological traditions found in other parts of the world.

The archaeological record of the Lower Paleolithic in Southern and Eastern Asian has given rise to a number of interpretations, many of them fundamentally flawed. The first major characterization of the area came in 1948 when Hallam L. Movis stated: "The archaeological, or paleo-ethnological, material very definitely indicates that as early as Lower Paleolithic times Southern and Eastern Asia as a whole was a region of cultural retardation" (Movis, 1948:411). Although subsequent research indicated that this interpretation was based on inadequate evidence, the methodological orientation derived from it, one in which all Pleistocene material culture was analyzed in relation to a classificatory scheme developed principally for the

Paleolithic of Western Europe, continued to influence the Western perception of East Asian lithic industries for many years (Olsen, 1978). Because most East Asian lithic industries do not conform well to the typological categories formulated for European archaeological assemblages, the Asian industries were seen not merely as dissimilar to European and African assemblages but, also as technologically and, hence, culturally retarded.

Compounding the problem has been the unrepresentative nature of the early collections. The Pleistocene collections made by de Chardin, Breuil, Licent, and others in the 1920's and 1930's are dominated by finished implements and clearly lack nuclei, utilized flakes, and debitage. One reason that these collections do not represent the full typological range of implements originally existing at their localities was the common practice of paying the local laborers for retrieving only "typical" specimens. There was no reward for broken or "atypical" specimens (Anderson, 1973). Another reason is that little consideration was given at the time to the natural agencies at work in site formation.

The past 20 years have seen a large number of important Paleolithic investigations in both China and India. Although not all of this material has been translated into English and not all of the collections made accessible to Western scholars, enough is known to alter the earlier views

and sweeping sociobehavioral interpretations that previously dominated the perception of the Asian Paleolithic.

The first point this study addresses is the notion that there are two mutually exclusive cultural lithic traditions in Southeast Asia. In the 1930's, the Joint American Southwest Asiatic Expedition for Early Man conducted a five-month field program in the Irrawaddy Valley of Upper Burma (Movius, 1948). Burma was selected because of its central geographical position with respect to the four regions in China where P. Teilhard de Chardin had worked. In addition, Hellmut de Terra had carried out research in Northwest India and Burma, and G. H. R. Von Koenigswald had worked in Java. In the 1940's, Movius sought, "...to provide a basic framework into which to fit the prehistoric archaeological material" from Punjab Province (northwestern India), the Irrawaddy Valley (Upper Burma), Choukoutien (northern China), and Patjitan in southern Java. "Movius" interpretation of these results in "Early Man and Pleistocene Stratigraphy in Southern and Eastern Asia" led to the recognition of a distinctive Paleolithic cultural development in southern and eastern Asia thought to have begun during Middle Pleistocene times.

Movius found variants of a Lower Paleolithic chopper-chopping tool complex in Java (the Paljitanian), Burma (the Anyathian), the Punjab (now Pakistan, the early Soanian), North China (the Choukoutienian), and possibly in the Malay

Penninsula (the Tampanian). By contrast, Movius notes, handaxes (coups-de-poing or bifaces) and flake implements made by the Levallois technique are found in peninsular India, Africa, the Middle East, and the southern, central and western regions of Europe. Because Movius' paper was a summary for anthropologists and prehistoric archaeologists, he omitted all detailed geological and paleontological arguments. The Chopper-chopping tool and Handaxe were thought to form "two mutually exclusive cultural spheres" (Ikawa-Smith, 1978).

As a result of World War II and its aftermath, international paleoanthropological research was greatly hindered. Many Asians viewed anthropology as a product of colonialism. They saw the European tradition, representing only one small part of human culture, dominating and judging the rest of the species. They resented being merely the subjects of such study. This situation continued to obstruct the pursuit of Asian paleoanthropology until the early 1970's.

In 1973, a conference on the East Asian Paleolithic was organized at McGill University by Fumiko Ikawa-Smith. By that time a large number of additional assemblages from continental and peninsular Asia as well as from China had been added to Movius' list. Some of the new assemblages did not appear to fit Movius' scheme, which led Ikawa-Smith to point out that "a conference on the Asian Paleolithic cannot

avoid the discussion of the proposition that the Paleolithic world was divided into two cultural areas, one in which fully bifacial handaxes predominated after a long initial "pebble tool" phase, and the other in which choppers and chopping tools continued until very late while handaxes were rare or absent" (Ikawa-Smith, 1978:3).

A.P. Khatri of the Indian Council of Scientific and Industrial Research, who was present at the conference, disagreed with the proposition of mutually exclusive cultures. His arguments were based on his work on the Mahadevian industries of the Narmada River region of central India, a region that falls into Movius' handaxe area (Khatri, 1963). The Mahadevian tools are made from big quartzite pebbles, shaped to form crude pebble tools bearing few flake-scars and resembling the Oldowan; there are no typical handaxes among these tools. Khatri thinks the Mahadevian "pebble culture" is contemporary with Acheulian assemblages, although at one site an Oldowan type assemblage appears to evolve into an Acheulian complex (Khatri, 1962).

Boriskovsky (1978) agrees that the Mahadevian represents the beginning of the Lower Paleolithic of south Asia. He believes, however, that the Mahadevian finds on the Narmada River are not distinct from the Pre-Soan type flake industries known to Movius (1944) from ten localities in northwestern India. Boriskovsky also notes that because handaxe or Acheulian industries are found in the Early

Soanian of the Punjab (Graziosi, 1964), the Soan assemblage is not different from those of the Lower Paleolithic of Madras to the south in Peninsular India. The Madras assemblage is made up of handaxes, cleavers, and a large proportion of choppers and chopping tools (Krishnaswami, 1947). Boriskovsky says: "It would be wrong to speak of the Lower Paleolithic culture of Soania as one lacking handaxes and cleavers, or of the Lower Paleolithic Madras culture as one having only handaxes and cleavers and no chopper-chopping tools. The discoveries made in recent years in Vietnam (Mount Do) and the Mongolian People's Republic (Okladnikov, 1978) show that lower Paleolithic handaxes are widely distributed in various parts of Asia" (Boriskovsky, 1978:90).

At the conclusion of the conference, Movius admitted that his attempt to "draw together the core and flake archaeological assemblages of South and East Asia into an integrated scheme must necessarily fall short of the mark." Yet, he complained that "scarcely anything substantive has been added to our general understanding of the fundamental problems of the core and flake assemblages of South and East Asia" (Movius, 1978:351). Ikawa-Smith summarizes the issue: "[while it] is probably true that the Paleolithic world was not composed of two mutually exclusive cultural spheres, there does not seem to be sufficient stratigraphic evidence from India or anywhere else in Asia to justify the

replacement, at this time, of the concept of separate technological traditions with a universal and unilinear evolutionary framework" (Ikawa-Smith, 1978:3).

A great many sites have been excavated since the 1973 East Asian Conference (e.g., Kao Pah Nam in northern Thailand, Pope, 1984; and Bose in southern China, Huang, 1988). Several of them appear to contain the stratigraphic evidence necessary to justify revising the concept of separate technological traditions. For example, in a brief summary of paleolithic study during 1980-1984 in China more than 40 sites are reported, with 20,000 lithic artifacts, and 500 bone and antler tools (Zhang 1984). Moreover, many of these sites contain artifacts that challenge the concept of separate technological traditions. And it is not only in China that this is the case.

In 1974, Sankalia reported finding some Paleolithic tools from the Liddar Valley, near Dahalgam, India. The collection comprises discoids and scrapers made of dolerite and quartzite (Agrawal 1982). According to Sankalia, this site, plus his 1969 finds of a massive flake and a crude handaxe from well-stratified deposits at Pahlgam in Kashmir, require us to reconsider the relationship between the Soan, or chopper-chopping tool culture, and the handaxe or biface culture in northwestern India (Sankalia 1971).

The fact that there is now enough evidence to enable reevaluation of Movius' framework brings us to the second

point addressed here, the relationship between typology, technology, and the available local raw material. This reconsideration goes to the heart of the claim that there was a form of technological or cultural retardation operating in Paleolithic Southeast Asia.

In this dissertation I concentrate on the stone tool collections themselves (classification, tool morphology, reductive technology, raw material type) and the archival materials that support them (fieldnotes, photos, manuscript reports, catalogs of artifacts), but this does not exhaust the information available from the lithic assemblages. A holistic approach to stone tool manufacture includes using the same local raw matrial in the replication of the archaeological lithic assemblages in order to assess its effect on artifact manufacture and artifact use. The type of raw material available as well as the size and shape will significantly affect the kind of artifact it is possible to produce. It is one thing to produce a tool from a uniformly textured chert nodule and quite another to produce one from a piece of quartzite full of irregular junctions and fractures. The differences found in this aspect of the assemblages challenges the inappropriate typological schemes, based on European and African assemblages, that have been applied to the Southeast Asian Paleolithic tool industries.

Nicholas Toth (1985) illustrates this point with his example of the Omo Valley in southern Ethiopia where the only apparent raw material consisted of small quartz pebbles. Because of the size and the mineral structure of the quartz pebbles, the tool forms found at the archaeological sites in this area consist of sharp quartz fragments made by flaking or smashing. Toth's point is that raw material availability determines much of the variability among tool assemblages.

Raw material resources differ among sites and regions as well as among the areas that Movius called separate technological traditions. In general, the raw material available to Old World Paleolithic tool producers and their contemporaries in Southern and Eastern Asia differs as substantially as do their collected assemblages. While raw material is not the only reason these assemblages display so much variation, it can certainly be shown to be an important determining factor. My replication experiments with the original raw material, supported by thin section examination of the properties of that material, provide a means to challenge the typological categories based on archaeological materials from Europe and Africa. Replication experiments are one means of demonstrating this fact. Mineralogical analyses of thin sections are another. A thin section is created by mechanically slicing and grinding a segment of the rock sample to approximately 0.03 mm. The thin section

is then mounted as a microscope slide. The resulting transparent or translucent view of the rock section makes it possible to study its structural properties. The description of the original hand sample of the raw material, and the more structurally explicit thin sections, along with replication experiments, provide a substantial basis to aid interpretation of a tool assemblage. The data for the thin sections was obtained by Robert Osborn of the Department of Earth and Planetary Sciences of Washington University. The material for the thin sections was taken from my replicated stone tools (I brought 5 to 10 replication samples from each of the Chinese sites, and a total of 10 from the India sites).

Still another aspect of the relationship between technology and raw material availabilty in southeastern Asia is the presence of bamboo. Some archaeologists believe that stone tools in southeastern Asia remained at a Lower Paleolithic level until protohistoric times because chopper-chopping tools and unretouched flakes are all that are required to cut and shape bamboo, an important raw material of the area (Bordes, 1978).

This line of thought is also discussed by Geoffrey Pope. Based on biostratigraphic evidence (primarily the lack of any savanna-dwelling animals in Pleistocene Southeast Asia), Pope believes that the areas Movius identifies as chopper-chopping tool zones were regions of

naturally occurring bamboo (Pope, 1989). Pope's hypothesis is that this "readaptation" to a tropical forest environment by early hominids "deemphasized the utilization of standard stone tools" (Pope, 1989). Pope's thesis is strenghtened by the obvious versatility of bamboo as a resource for tool making. Bamboo tools would have been highly portable, fairly efficient, and reasonably durable. Unfortunately, it is also very unlikely that they would be preserved at archaeological sites.

Following Bordes' suggestion, a number of archaeologists have inferred that the stone choppers and resultant "waste" flakes found in Asian sites were created in order to manufacture nonlithic, primarily bamboo, tools. Experiments in the use of stone flakes on bamboo show that when the angle of the working edge of the tool is 50 degrees or more, it will not incise or notch the bamboo more deeply than about 0.5 cm. After this initial notching the sides of the incision rub against the side of the tool, substantially decreasing its effectiveness (Shannon, personal communication, 1988). Yet, even with a notch of only 0.5cm., the bamboo can be broken fairly evenly by striking it against a tree or the ground. A working edge of less than 30 degrees is far more effective at producing a deeper notch, which results in the ability to shape the bamboo more effectively. These preliminary experimental results suggest that the simple flakes struck off in the production of

choppers may have been tools at least as important as the chopper itself. Bamboo tools can also be produced by smashing the bamboo and shaping the splinters into projectile points or stabbing implements.

It is not at all clear, however, that the requirements for working bamboo alone are a priori sufficient to account for the presence of distinctive Asian and European stone tool traditions. Certainly the bamboo alternative does little to explain the variability found within the so-called chopper-chopping tradition. However, the bamboo alternative together with detailed study of the tool making potential of the available raw material does offer a foundation for reassessing sweeping socio-behaviorial claims based on the differences between Asian Paleolithic assemblages and those from Europe and Africa.

There is simply not enough evidence to make the inference that a simple stone tool technology reflects "technological or cultural retardation" or low cognitive ability. Lithic technology may not accurately reflect cognitive ability. Nor does such an inference take into account the non-surviving nonlithic technology, which may be a more precise reflection of cognitive ability. The inference of a technologically-based cognitive threshhold does not appear to fit the facts. Nicholas Toth notes that some Southeast Asian, Australian, Tasmanian, and North American west coast late Pleistocene and Holocene

assemblages, assemblages that are certainly the products of *Homo sapiens sapiens*, are basically chopper-chopping assemblages (Toth 1985).

The solution to this problem is as simple as it is practical. By replicating each assemblage that I studied I was able to show that the type of raw material used goes a long way toward determining the typology and technology of the end product. Technologically, it is far more difficult to shape a cobble into a symmetrical, straight-edged tool than it is to shape it into a chopper-chopping tool, with some very useful sharp flakes being produced in the process. Moreover, even from the chopper-chopping tool assemblages, it is obvious that these early tool producers were able to make use of the mechanics of stone fracture and find the appropriate angles from which to strike off flakes. Manufacturing stone tools from a brittle and junctured quartzite or a planar structured limestone is every bit as cognitively challenging as producing a symmetrical straight edge from a uniformly structured chert.

2. Definition of Terms

The first key concept for the present analysis is the "Chopper-Chopping tool". The original definition was given to this category by Movius (Movius, 1949) and was employed in order to describe Lower Palaeolithic cultures of the Early Anyathian (Burma), Soanian (Northwest India),

Choukoutienian (North China), and Patjitanian (Java) types. Although Movius' terminology is based on form and technique of manufacture, the names he uses imply function. In Movius' original terms, the "Chopper-Chopping tools" included two separate categories: Choppers and/or Scrapers, and Chopping-Tools. Movius states, "normally a chopper is made on a core - either a pebble or an angular chunk of rock - whereas scrapers are usually made on flakes". But large crude scrapers and massive scrapers are also called choppers. Both are formed by the removal of flakes from the upper surface unifacially only. This type of unifacial tool normally has a round, semi-oval, or straight cutting edge (Movius, 1949:36).

Chopping-Tools are "core implements usually made on pebbles, or rough, more or less tabular, chunks of rock, with a cutting edge that has been worked from both sides. This edge is usually markedly sinuous, since in the majority of cases it is produced by alternate flaking, or rather by the intersection of alternating flake scars. This results in the formation of an edge that is in the form of a broad W." (Movius, 1949:36). They are bifacial artifacts in the sense that the cutting-edge has been worked from both sides. In other words, Chopping-Tools are bifacially flaked Choppers; they belong to the same basic form and technique of manufacture as Choppers and/or Scraper tools, but are bifacially flaked.

In a more recent study, Leakey revised these terms as used for the Oldowan, Developed Oldowan, and Acheulian assemblages. Choppers "are usually made on cobblestones with rounded cortex forming the butt ends. ... In the majority the trimming is bifacial, with multi-directional flaking of the working edges" (Leakey, 1971:4). The Scrapers have been subdivided into two main groups, namely heavy-duty and light-duty. Heavy-duty scrapers "are often made from pieces of tabular quartzite, steeply trimmed on one or more sides and with the upper and lower faces formed by natural flat cleavage planes". Light-duty scrapers "are made from parts of cobblestones or on large flakes" (Leakey, 1971:6). Leakey also use the words "large flake", but only for the light-duty scrapers (the largest measurements of length/breadth are 63x52 mm.); it is quite obvious that Leakey's definition differs from Movious's (large crude scrapers made on large flakes). Moreover, Leakey's Choppers are often formed bifacially, but Movious' Choppers are more commonly made unifacially. Although Movius and Leakey both use the terms "Choppers and/or scrapers", their meanings are significantly different. According to these definitions, a "large flake tool" could be both a chopper and a scraper. This kind of confusion illustrates the difficulties of any classification that conflates form and function.

The other issue to be addressed here is the type of stone-tool industry conventionally known to archaeologists

as Acheulian. Acheulian industries first appear in the archaeological record in East Africa. The name, however, is derived from Saint Acheul in the Somme Valley of northern France, which is one of the places where these characteristic stone artifacts were first recognized. By the end of 1905, the objects recovered from the Saint Acheul site were 968 flakes, 92 cores, 20 hammers, 70 other tools of various sorts, and only 15 handaxes. The Acheulian industry has been defined by the variable frequency of these handaxes or bifaces.

According to Francois Bordes (Bordes 1968), the transition from the Chopping-tool to the true Handaxe "would appear to have taken place as follows: first, a development of retouching all round the pebble, except at the butt, giving proto-handaxes; then the extension of this retouching to the whole upper and lower surface of the pebble; and finally a total retouching doing away with the butt altogether. ... For a long time the handaxe remains asymmetrical, trihedral in section, with one face flatter than the other; then it becomes symmetrical in section." The earliest hand-axes tend to be crudely shaped, few flakes have been removed from them, and the scars marking the positions of these flakes are deep, suggesting that a simple stone hammer was used to detach them. These handaxes are usually thick in relation to their breadth. Although crude examples may continue, in later assemblages there are also

many more finely flaked specimens with shallow scars such as may have been produced by use of soft hammer or by indirect percussion.

In many Acheulian assemblages, particularly in Africa and India, there are also implements known as cleavers. Similar in size and mode of production to the handaxes, these are often made on large flakes and have a straight transverse cutting edge in place of the point. Numerous flakes, both those removed in the course of handaxe production and others, were used untrimmed as cutting and scraping tools.

In the following study, aided by replication of Early Paleolithic lithic assemblages, I describe the technological system involved in the manufacturing sequence. I do this in order to avoid the problems involved with conflating morphological attributes and typologies with supposed functions of the tools being described. I also believe that referring to the reduction stages in the manufacturing process is a much more accurate method of appreciating and explaining the range of variation found in a tool tradition and the raw material from which it is produced.

In this approach I follow Jeffery Flenniken's proposal that flintknappers, be they the original or replicators, do not have mental templates as "the idea of the proper form of an object" in their minds when they begin work on a stone. "Rather, they employ a `culturally' determined reduction

technique that is selected to reduce a specific size, shape, and geological type of lithic material into a tool that is *within* the acceptable range of cultural (both form and function) variation ..." (Flenniken, 1984:191). Variation, then, is the end result of a number of variables, the two most important being the flintknapper's skills, and the restrictions inherent in the geological attributes of the available lithic material (such as types, sizes, shape, crystallinity, cortex).

By concentrating on the reduction technique, which is the specific sequence of stages and their respective debitage, I can explain the variations of technology and behavior found between so-called "tool traditions". Using this approach one first examines the collections and then replicates a number of them in order to discover what Flenniken calls the "culturally determined reduction technique". From this reduction sequence is built a "replicative system analysis", which deals with interaction between the technological skills of the knapper, the knapping tools, collection of the debitage, and the restrictions inherent in the raw material.

I refer to the reduction stages in the manufacturing process as results that are usually defined as types. This classification scheme produces groupings of artifacts that are first divided into two categories: core and flake. There are 18 types of core tools and 25 types of flake tools

in this study. Second, in each category, edge configuration is evaluated according to whether the tool has bifacial or unifacial edges. There are 8 types of core with unifacial edges, 8 types with bifacial edges, 2 types of core tool in other shapes, and debitage cores. The category "Flake with Unifacial Edges" includes 11 types, as does the category "Flake with Bifacial edges". Three other flake tool types are "Flakes in Other Shapes", "Unmodified Flakes", and "Debitage Flakes". Next under the bifacial or unifacial edge heading comes the process of manufacture, which defines the shape of the tool. For example, the category of "Flake with Unifacial Edges" defines the manufacture of a single lateral edge, double lateral edges, distal end perpendicular to double lateral edges, distal point, leaf-shaped distal end, leaf-shaped proximal and distal ends, distal end, proximal end, distal and proximal ends, and all edges (for detail see Table 1).

3. Research Methods

The major focus of my fieldwork was the tools themselves, so my primary concerns were the stone tool collections and the supporting archival materials in local museums, archaeological laboratories, and store rooms. The availability of complete collections was not always under my

control, and I recognize the serious limitation this brings to my study. Unfortunately, many of the limitations placed on my access to the collections were political in nature and would confront any researcher. I did the best I could with the material I was allowed to see, however, and I believe that while some of my individual samples are statistically weak, the sum total of my observations make a compelling argument. Complicated statistical tests lie beyond the data base of the small proportion of specimens I was able to use for the eight archaeological sites, but, the percentages and other simple descriptive data provide an adequate basis for valid inter-site comparisons.

Fieldwork began March, 1988, in Beijing, China. This work was begun by permission of the Institute of Vertabrate Paleontology and Paleoanthropology (IVPP), Academia Sinica in Beijing. This permission included the qualification that I could not go into the warehouse to pick up the specimens, and that I could work with the collections in the office only if an IVPP member brought the specimens out of the warehouse for me to study. The IVPP warehouse contains the specimens that were discovered by their own teams, and also contains material recovered from most of the provinces of China since the 1920s.

All the collections had undergone preliminary research, and articles on most of them had already been published. I selected the sample sites by the following criteria:

1. Reliable chronological placement, preferably with fossiliferous Pleistocene deposits to help support the dating of the site.

2. Sufficient size and diversity of assemblages to support their use as representative examples of the locales from which they come.

3. Inclusion of a variety of tool-making traditions (particularly handaxes and choppers or chopping tools), so that patterning in the selection of raw materials, and in the relationship of raw materials to stone tool type, could be investigated.

The specimens that examined in this study included Lantian, Liangshan, and Shilongtou kept in the IVPP warehouse. The excavated artifacts from Guanyindong are kept in Li Yanxian's office. He chose a total of 59 specimens for my study, which represented each type included in the original stone tool assemblage. The Bose collections are in three places. Some specimens collected by Qiu Zhonglang and Huang Weiwen of the IVPP are in the Bejing IVPP warehouse and are included in my study. Other groups of these specimens are under the control of each of the two researchers, and still others are in the local museum. Hence, either a complete or partial stone tool assemblage from each of the five Chinese sites in my study is among the collections of the IVPP.

I examined the original excavation reports, and I interviewed the excavators about previous work. These discussions usually included the geological background of the locality, the stratigraphy of the excavation, dating, the methods and techniques of excavation, and the possible sources of lithics used in each stone tool assemblage. This information was always the first material I used when beginning the study of each site.

It took approximately three months at the IVPP to record each specimen in the study. First I measured the length, breadth and thickness, and weight; and made observations on the extent and location of edge damage, the type of raw material, the quality of raw material, the amount of cortex remaining, and the direction of striking on both core and flake specimens. I then recorded the number of flake scars on each core specimen; the platform thickness, breadth, and angle; the number of scars on the platform, the number of dorsal scars, and the number of ventral scars on flake specimens. I also took photographs and drew pictures of each specimen (drawings at a scale of 1:1). These data documented tool morphology, and also enabled me to classify and define the reductive technique used in making the tools.

While at IVPP, I accompanied Diane Gifford-Gonzalez on a visit to the Donggutou site in the Nihewan Beds of the Lower Pleistocene. A large number (13,650 pieces) of stone

artifacts were excavated there in 1974-76, and, except for a few core tools, were all made on small flakes. Such an advanced industry discovered in an old stratum is an interesting problem confronting paleolithic archaeologists and quaternary geologists (Desmond Clark, Nicholas Toth, Kathy Schick, and the IVPP worked on the Donggutou site in 1991). Two points from this site struck me as particularly important: one is the geological environment at that early time; the other, is that the Nihewan fauna were mostly extinct by the time of the Quaternary. There is a clear distinction between the fauna of the Neogene and those of the Pleistocene. But there is almost no division of Quaternary faunas, especially between the early Pleistocene and the middle Pleistocene. This situation is the source of continual argument in China concerning the dating of Middle Pleistocene sites. I studied the Nihewan site as a good start for my next step, work in the field.

In the middle of June 1988, I visited Guanyindong with Wei Qi of the IVPP and Geoffery Pope of the University of Illinois. They helped me contact the Institute of Mountainous Region Resources (IMRR), Guizhou Academy of Sciences, so I could begin my work. Cao Zetian from the IMRR had worked in co-operation with the staff of the Provincial Museum of Guizhou and the field team of the IVPP in the 1964 test excavation of the Guanyindong site. He is the authority on this site.

When we visited the cave site, Shen Guanjun from the Chemistry Department of Guizhou University collected some new samples of the stalagmite canopy on the cave wall and the layer of stalagmitic crust. The results of uranium series dates from this new sample are introduced in the chapter on Guanyindong. Cao agreed to let his assistant, Zhang Pu, help me during my work in Guanyindong. It took about 10 days to find the source of the chert nodules used as raw material by the Guanyindong flintkappers. The source is in Jinyan village, which is some 4,500 meters (by the most direct route) from the cave site. The local people collected 150 kilograms of chert nodules for me, and for another 10 days I carried out replication work on the stone tool assemblages.

I tried to go to Lantian in Shaanxi province in the middle of August, but the road was blocked by floodwater, so I had to postpone my trip until the beginning of September. At that time I worked for several days with Wei Jingwu and Yin Shenpin of the Shaanxi Province Institute of Archaeology, both had done research in the Liangshan area previously. They showed me some 200 artifacts collected during their work, and I recorded ten of them. The institution appointed archaeologist Hu Lingui to be my assistant during my time in Shaanxi province. I spent 13 days climbing and investigating in the Liangshan Mountains. and the ancient gravels of the Hanshui River, and in

carrying out my replication work. Next I went to the Ba river, the location of the original Lantian Man find. Here I stayed at the Lantian Museum, which is located half way up Gongwangling hill. Quartzite was used as the raw material by the ancient Lantian people, and while it was easy to find, the cobbles are rather large, so it is not very easy to carry around. Gongwangling is without doubt a good place for early hominids.

On October 10, 1988, I flew to Hubei province to work on the Shilongtou site next to the Yangtze river. Li Tianyuan, who excavated the Shilongtou site in 1989 and has worked in this area for twenty years, consulted with me at the site. Because I had a difficult time identifying the original raw material (quartzite cobbles) that was taken from an ancient gravel layer next to Daye lake or the tributaries of the Yangtze River near the Shilongtou site, he suggested we visit a similar environment at a cave site called Jiudaohe adjacent to the Yangtze river. The only difference between the situation of these two cave sites is that there is a small river passing below the entrance of Jiudaohe, and there are quartzite cobbles along the river bank. The example of Jiudaohe helped me reconstruct the hominid lifeway at Shilongtou. The replication work at Shilongtou site took about 15 days, and I left Hubei province October 27.

In the middle of November, with the support and collaboration of Huang Weiwen and Yuan Xiaofeng of IVPP, the Museum of Guangxi Zhuang Autonomous Region, and the Cultural Relics Museum of Bose, we carried out a small (36 square meters) excavation at Posuan village in the Bose area. The purpose of the excavation was to clarify the relationship between the third and fourth terraces in this area. The composition of the core specimens, small flakes, and chips in the artifact assemblage indicate that the laterite sediments of the strata represent an ancient knapping location. This lateritized layer belongs to the fourth terrace in the excavation area, and there are large silicified limestone cobbles in the ancient You River gravel. The distance from the source of the raw material to the excavation location is about 100 meters. The replication work in Bose took about two weeks, and Huang and Yuan provided a great deal of help.

In late November, I opened the first Chinese flintknapping field school, which was held at the Neolithic Xiqiaoshan quarry site in Guangdong. The field school was supported by the Department of Anthropology of Zhongshan University and Nanhai County Museum. The students were from IVPP, Hubei Provincial Museum, Zhongshan University, Guangdong Provincial Museum, Guangdong Provincial Cultural Relics Bureau, and Nanhai County Museum. Every morning I lectured about the theoretical basis of experimental

archaeology, lithic technology, and flintknapping. In the afternoon, we did flintknapping work. The raw material was quarried from the Xiqiaoshan limestone cave. (Silicified limestone is very easy to work and later I found this same kind of limestone has been used in the Hunsgi site). The field school lasted only eight days. During this time I also thought through my systematic study of the work on the five archaeological sites in China. Such field schools should be especially valuable by adding experimental are important because they add experimental archaeology, especially flintknapping, to Chinese archaeological research.

I did not visit the Sure site in northern Tibet, as originally scheduled, because the open border crossing between China and Nepal at Zhangmu (Zhangmu was opened as a trading post in 1980) was closed in 1988. I could not enter Nepal from Tibet and proceed to Kashmir in India. Hence, I had to fly to India from Hong Kong.

On December 25, 1988, I arrived in Bombay, India. Prof. Paddayya of the Archaeological Department of Deccan College was the host for my fieldwork in India. As in China, I first spent about two weeks studying in the library and the museum of Deccan College. Talking to the archaeologists, geologists, paleontologists, and geomorphologists in the college gave me valuable information about the Indian Paleolithic culture.

Because the Kashmir and Punjab areas (where the Early Soanian artifacts were widely distributed in river gravels) were closed to foreigners at that time, I had to give up another part of my original plan. My fieldwork in India finally focused on work with the stone tool assemblages from three Lower Paleolithic sites: Bhimbetka, Durkadi, and Hunsgi. The excavation artifacts from Durkadi and Hunsgi are stored in the college museum, but I recorded sample specimens from the collections.

In the middle of January, 1989, I joined the excavation at Samnapur village. Samnapur is roughly twenty miles from the Narsenghpur train station. The dig was carried out by V.N. Mishra, the chairman of the Archaeology Department of Deccan College. Samnapur is about 1 mile north of the Narmada river, on a open spot surrounded by many hills. The excavation was on a horizontal plane and covered an area of 10x10 square meters. The stone artifacts densely covered the trench floor in the culture layer, which was only one meter thick. There were basically cores, flakes, and blocks; the tools are trimmed unifacially or bifacially on one or two edges. Mishra thinks the site is later than the Acheulian layer, because he saw some old terraces that contain handaxes in the lower level, with the kinds of stone tools he found in Samnapur on top.

This use of a comparative study between two or three different technologies to date them relative to each other

is a tendency I found among some Indian archaeologists. To use this method to date a tool, one must have an overall understanding and knowledge of the deposits from which the early stone tool assemblages come, their typology, and the distribution of different technologies in India. I think it is difficult to do any wide ranging comparison of typologies because even if one found differences between types, those differences could not explain the technological differences, or it may be that the same technology was used to make different types of tools. To use only tool types to date a site is very risky. In Asia this is especially true if standard tool types from Europe are used as reference points in this exercise because there are many different kinds of local environmental circumstances in Asia.

I was in the excavation site at Samnapur for one week. I observed and learned the methods and techniques of excavation and artifact recovery practised by Indian archaeologists. The archaeological students in the excavation slowly and methodically went through every small piece of soil by hand, so they would not miss any chips in the deposits (no screens were used).

Bhimbetka was the first site I visited for my study, I went to Bhopal (locale of the Union Carbide disaster), and obtained permission to work at this site from the Central Circle of the Archaeological Survey of India. The State Archaeology Museum delegated an archaeologist to lead me to

the cave the first day in order to introduce us to the guard at the Bhimbetka site. The closest housing was in Bhopal; from there it was a two-hour bus ride and a thirty minute walk to the site. The replication work was done on the hill close to the site and took seven days.

After the work at Bhimbetka, I traveled directly to Vikram University, in Ujjain, to see the artifacts excavated by Wakankar in 1972 and stored in the University's museum. The director of the museum, D.S. Solanki, took me to study the excavation artifacts. All Wakankar's collections were laid out on the roof of the museum, exposed to the light of day and the forces of the weather. I was permitted to examine only ten of the artifacts, although I was able to see and casually examine the entire collection on the roof. The visit proved one thing that is very important, namely that the tools were made of river cobbles from the lower layer of the Lower Paleolithic period deposits. Mixed with these tools made from river cobbles were some artifacts made of sandstone. Solanki told me that someday soon he would complete the work that Wakankar did not finish.

The second site I studied in India was Durkadi Nala. I began work there at the beginning of February. Because I was out of drinking water, and suffering some dehydration from a bout of diarrhea, I was able to work at this site for only three days. Under these conditions the replication work was very difficult, but I was able to identify the raw

material used for the stone tool assemblages and to locate the source of this raw material, ancient river gravel that is about 1,000 meters from the site. The quality of the quartzite around the Narmada river is very similar to the quartzite cobbles from the Ba and Hanshui Rivers in China. I did some replication work, but I did not record any of the resulting tools, because I was hoping that I could go back to the site later when I had the parts to fix my water purifier.

In the middle of February, I visited the Hunsgi site. Here I was greeted with the warning that 75 percent of the village people had malaria due to standing water created by the new irrigation system around the village. Despite this ominous beginning, I was fortunate to have Mr. Basappa, a local teacher who had helped Paddaya in excavations in this area since 1974, to lead my investigation of the Hunsgi valley. Basappa knew the location of all the archaeological sites and the source of the limestone used as raw material by the ancient Hunsgi knappers. I was also lucky here because the local people had gathered many limestone blocks from the limestone plateau and brought them to the valley for use as material to make walls. I did not have to quarry raw material myself; rather I used the ready-made limestone blocks to finish my replication work within five days.

In the beginning of February, Prof. Bridget Allchin of Cambridge University visited Deccan college and gave a talk

entitled "Potwar Paleolithic: an Overview of the Work of the British Archaeological Mission to Pakistan". This was a very important topic for me. The Potwar Plateau lies at the foot of the Siwalik hills in Pakistan. The hills are composed of sedimentary deposits, which were laid down in a deep basin by Himalayan rivers during Early Miocene to Middle Pleistocene times. The deposits were faulted and folded on several occasions and have been cut through by rivers originating in the Himalayas as well as by small local streams.

In the 1939 investigation, de Terra and Patterson set forth a sequence of four glacial and three interglacial periods based on the Upper Siwalik sediments and the terraces formed on them by erosional and aggregational agencies. Ms. Allchin said that the recent results of the British Archaeological Mission in Pakistan have shown de Terra and Paterson's geological and climatic progression and archaeological sequence to be considerably too simple. The mission has not found evidence of the existence of independent Acheulian and Soanian technological traditions. Instead, they located extensive lithic workshops on Lei and Siwalik conglomerates covered by loess. The archaeological component of these sites consists of choppers, flakes, blades, cores, and occasional handaxes, most of which were in mint condition. The most important and controversial recent finding in the area, a pebble tool covered by

volcanic ash, might move the date from 700,000-400,000 y BP. to 1 million years ago. Had I been able to visit the British Archaeological Mission in Pakistan, I could have learned a good deal about the features of the ancient river terraces, and about geological sedimentary deposits in the area. Unfortunately, despite trying and waiting in New Dehli for seven days, I was unable to obtain a visa to visit Pakistan.

Instead, I visited Kathmandu valley in Nepal. Nepal had been an enigma for me when I worked in Tibet. Archaeological work has been carried out around the Himalayan foothills since 1960 (Ghosh, Joshi, Banerjee, and Sharma), with the first evidence of the presence of *Ramapithecus* along the Tinau Khola, in the Nepalese Siwaliks. This is an important find that will help build a stratigraphic base for future paleoenvironmental research in the area.

In 1984-85, Gudrun Corvinus found some artifacts at the foot of the mountains in the Dang and Deokhuri Dunes. In his original report, one can see that the stone tools are made of well-chosen quartzite cobbles, which retain a natural cortex. There are cores, flakes, and a handaxe-like tool. From these discoveries it is inferred that prehistoric people penetrated these Himalayan valleys via the heavily forested Siwalik mountains. In order to obtain a quick overview of the foothills, I took a two day mountain

bike trip to Nagakot, a small mountain village overlooking the Himalayan range. I then trekked along the Indrawti river to the Buriang Bhanjyang mountains where there is a glacier valley. The Himalayan mountains are beyond these foothills. Although I did not find any stone tools during this five day investigation, it was a valuable experience to observe the landscape of the mountains and forests.

I returned to India in the middle of March, and gave a presentation of my thesis and a report on my field experiments to the faculty and students at Deccan College. They were very surprised to see the replication work that I had done in Bhimbetka and Hunsgi, and found it very difficult to believe how similar my work was to the original artifacts. I had hoped to do a little more work in India, such as revisit the Durkadi Nala site, but was unable to obtain an extension of my visa, not even for two weeks.

I left India at the end of March, and flew to Thailand. The background to this visit began with the discovery (by a Dutch archaeologist named van Heekeren) of the earliest Lower Paleolithic tools yet known in Thailand. Van Heekeren, found the tools during the building of the railway line from Kanchanaburi, Thailand, to Burma in World War II. These implements were identified by Movius as stone tools made by *Pithecanthropus* or *Homo erectus* of Java and China; Thailand was considered a migratory route leading to those countries. Since Movius's pronouncement, more than 3,000

Paleolithic tools have been found in Thailand. Thai archaeologists have suggested that Thailand was not only a migratory route, but that it also served as a living area for groups of hominids. Moreover, in the 1979-80 field season, the joint Thai-American Expedition excavated a site at Kao Pah Nam, in Lampang province of northern Thailand (Pope, 1981). Preliminary results indicate that the Kao Pah Nam fauna is probably of at least Middle Pleistocene age. They believe that this location may be the oldest hominid site in mainland southeast Asia.

Geoffery Pope had provided me with an introduction to his Thai colleagues, Vadhana Subhavan and Somsak Prankij at the Museum of Prehistory, Mahidol University, Siriraj Hospital. Ms. Subhavan and Mr. Prankij, who is a very skilled flintknapper, kindly accompanied me to the Kao Pah Nam site. The area is a highly dissected and weathered limestone karst, which outcrops about 0.1 km. from the Mae Nam Wang river. Fossils occur in a range of sedimentological contexts resulting from the accumulation of bones in what is interpreted as a palaeo-cave or palaeo-rockshelter. Somsak told me that the fossils are in limestone breccia and in an overlying and sometimes underlying soil zone. Fossils, angular limestone chunks, and fragments of quartz pebbles were poorly sorted in a fine-grained matrix held together by calcite cement. There were three non-limestone rocks: a split river cobble, a

bipolar-flaked cobble, and a small chert flake (Pope's description). One bone (the only one in the excavation report) appears to have been "chopped" or "sawed" in order to produce a flat surface. The evidence indicates to Pope that the Kap Pah Nam rockshelter can be dated to the pre-Hoabinhian period (K-Ar ages of the Hoabinhian industry are 0.8 and 0.6 million years).

There are quartzite cobbles in the forest around the cave site. These cobbles have been changed by long exposure to the weather, they have varying colors and shapes, and most of them can only be called blanks. I was very surprised to find that there is bamboo in the forest here, also. Charles Shannon who was working with me here, did some experiments by using different sizes and angles of stone flakes to cut the local bamboo. This work is quite difficult, and the time to cut down a bamboo stalk is almost equal to the time required to manufacture a flake tool (see the Summary). We were there during the dry season, so it is possible that the bamboo was harder to work than it would be during the monsoon.

I took a trip to the famous "Golden Triangle" which is formed by the borders of Thailand, Burma, and Laos. The Mekong river (whose source is on the Qinghai Plateau within China, where it is called the Lancang river) separates these three countries. The Neolithic site of Karuo in Qamdo, Tibet, is on the west bank of the Lancang river. I worked

on this site for several field seasons in 1978 and 1979, which is the main reason I wanted to see the Mekong river. When the bus passed the Chiang Mai Basin, I could see red lateritic deposits just like those at Bose Basin. I also visited the Lahu, Akha, and Mae Salong hilltribes, most of whom probably came from China one or two generations ago. There was Chinese writing on the walls inside their houses, although not many people are able to speak Chinese anymore. In early May, I returned to China.

4. Summary

Through a combination of interviews with the original excavators, careful recording of the stone tool collections, reading the supporting archival materials, gathering information concerning technological methods and techniques, examining the geological features in the site localities, and using local appropriate raw material to replicate the ancient archaeological assemblages, I compiled a body of information relevant to each Paleolithic stone tool assemblage concerning the manufacturing process or reduction sequence.

For each site (Chapters 2 through 9), information on the initial discovery is included in the section called "Geological and Archaeological Background." Detailed information on the stone tool assemblages themselves is in the "Description and Classification" section, the beginning

of which concerns "Previous Work" and provides background on the original excavator's or other researchers' work, as well as other opinions about the site. The second section, "The Collection", discusses the categories of the stone tool specimens and sorts them into my own classification. The last part, "Analysis and Replication", reports the results of lithic analysis that defines the major dimensions of the range of variability within an assemblage. These matters are further discussed under "Technology".

The section on "Selection of Raw Lithic Material" describes how I located the source of the raw material, and gives the dimensions of the raw materials I used in replicating the original tools. Also provided here are the results of the thin section examinations of the different rock types and their relationship to the potential flaking and production of tools. "Reduction Sequence" is discussed at the conclusion of each site chapter. Each such reduction strategy is described from the perspective of the lithic raw material used. Hence each site has its own emphasis as seen in the ratio between the average dimensional data of primary raw lithic material, the final shapes of tools, and other data necessary for understanding the amount and degree of reduction necessary for tool production of a particular series of tools. In the final chapter I summarize the information obtained from each of the eight sites in the

study, and present my conclusions as well as some suggestions about the Southeast Asian Lower Paleolithic.

Chapter 2 Lantian

In 1963, a lower jaw of *Homo erectus* was found at Chenjiawo in the northwestern part of Lantian county, Shaanxi province (Fig. I 1). From 1963 to 1966, excavations at Gongwangling in the same county totalled 1,954 square meters. Within this three year excavation period, 27 localities of the Middle Pleistocene horizon in the Lantian area yielded about 200 stone artifacts made of vein-quartz and quartzite cobbles. In the summer of 1964, the Institute of Vertebrate Paleontology & Paleoanthropology (IVPP) and the Institute of Archaeology of Shaanxi Province unearthed a fossil human cranium during a comprehensive survey of the Cenozoic at Gongwangling. The fossil was named *Homo erectus lantianensis*, popularly called "Lantian Man". The mammalian fossils found together with the human remains are called the "Gongwangling Fauna".

1. Geological and Archaeological Background

Location

Lantian county is in the southeastern part of the Guanzhong Plain, and is bordered to the south and southeast by the Qinling Mountains. The Wei River is to the north and the Chan River to the west. Gongwangling is 17 km southeast of the Lantian county seat, 66 km southeast of Xi'an city. It is 34.18 degrees north latitude, 109.2 degrees east

longitude. Chenjiawo is on the north side of Ba River (the Lantian Man locality is on the south side of this river), 20 km away.

Dating

The magnetostratigraphic age of the loess profile in the Lantian human fossil beds has been estimated several times. The first was about 0.75-0.80 myr for the Gongwangling locality, 0.65 myr for the Chenjiawo locality (Ma *et al.*, 1978); the second was about 1 myr for Gongwangling and 0.5 myr for Chenjiawo (Cheng *et al.*, 1978). The most recent report states that "the cranium found in the fossil-bearing strata at Gongwangling is about 1.15 myr old whereas the remains found at the Chenjiawo locality in middle Pleistocene loess are about 0.65 myr old" (An *et al.*, 1989). According to the authors of this most recent report, the newest dating is based on paleomagnetic polarity determinations and on the lithostratigraphic position of the fossils in the loess-paleosol sequence. The Lantian human fossil and associated faunas are located in the 9th layer of the loess sequence, which corresponds to the middle part of the silty loess L15 at Luochuan that has been dated from 1.09 to 1.20 myr.

Another study of chronological correlation of early human fossil horizons with deep sea loess records demonstrated that the climatic curve drawn from the loess-paleosoil series of the loess profile running from late

Matuyama subchron to the present at Luochuan, Shaanxi province, could be correlated with the oxygen isotope records of core V28-238. The Gongwangling Lantian Man fossil bed is in the 9th layer of the loess sequence (cycle IX), corresponding to termination X of the deep-sea records and to stage 20-21 of O18 isotope stages: 0.73-0.80 myr. The Chenjiawo Man fossil bed is located in the 6th paleosol of the loess sequence (cycle VI), having an age of 0.50-0.59 myr (Liu *et al.*, 1984, An *et al.* Fig. I 2). Because the dates for the human fossils in the Lantian area have been getting earlier and earlier, there is little problem in suggesting that the Gongwangling and Chenjiawo localities belong to the Middle Pleistocene period.

Hominid Remains

The morphological features of the fossil from Gongwangling indicate a more primitive *Homo erectus* form than Peking Man (Wu, 1966). The cranium of *lantianensis* is characterized by a much wider frontal tuberosity than that of *Homo erectus*. *Lantianensis* also has a large zygomatic right arch, and large brow ridges; the constriction behind the brow ridges is less marked than in *A. africanus*, and there is a remarkable frontal crest. The skull's forehead was much lower and more sloping than those of living humans (Fig. I 3). The cranial capacity of Lantian Man is about 775-783cc, larger than almost all australopithecine skulls

(400-550cc), but similar to *Pithecanthropus robustus* (775-900cc) and smaller than Peking Man (850-1300cc). The Lantian specimen has a very thick skull (16 mm.) compared to Peking Man (7.0-9.9 mm.). The maxilla of Lantian man forms a uniform arch shape, and the premolars and molars are not very large in comparison with the front teeth, which distinguishes the Lantian specimen from *Australopitheus africanus*. The morphological features of the lower jaw of the specimen found at Chenjiawo are very similar to Peking Man, but there are some differences. It is very difficult to compare this mandible with the specimen from Gongwangling, because the latter lacks a mandible. Wu Rukang thinks that the features of the upper and lower jaws, and the size of the teeth indicate that the two are similar, so he describes the specimen found at Chenjiawo as *Sinanthropus lantianensis* (Wu, 1966).

Faunal Remains

The Gongwangling Faunal assemblages contain 25 species: *Leptobos, Ursus thibetanus kokeni Matthew et Granger, Rhinoceros, Hyaena sinensis Owen, Rusa, Canis variabilis Pei, Nyctereutes sinensis (Schlosser), Mustela, Meles, Megantereon, Acinonyx, Equus sanmeniensis Teilhard et Piveteau, Sus lydekkeri Zdansky, Gazella, Macacus robustus Young, Panthera pardus Linne, Felis cf. youngi Pei, Pseudaxis grayi Zdansky, Sinomegaceros, Ailuropoda*

melanoleuca Milne-Edwards, Stegodon cf. orientalis Owen, Tapirus sinensis Owen, Nestoritherium cf. sinense Owen, Elaphodus cephalophus Milne-Edwards, and *Hystrix cf. subcristata Swinhoe* (Zhou, 1965, Fig. I 4). These comprise *Carnivora* (11), *Perissodactyla* (4), *Avtiodactyla* (7), *Primates* (1), *Rodentia* (1), and *Proboscidea* (1).

The Gongwangling Faunal assemblage is similar to fauna from the south of China and the south part of Asia during the Middle Pleistocene, but the Gongwangling Fauna comes from the northerly portion of the Qinling Mountains. These mountains are regarded by most geographers today as the line of demarcation between north and south China. Previously it was believed that the species of *Ailuropoda, Acinonyx, Stegodon, Tapirus, Nestoritherium, Elaphodus,* and *Rusa* were extinct in the north part of Asia after the Middle Pleistocene, but these species are prominent in the Pleistocene fauna of south China (typically in the locality of Yanjinggou, Wan county, Sichuan province), and in southern Asia. The question is why the Gongwangling Fauna in north China, is similar to the South China Fauna. There are two reasons: first the geographical position of Gongwangling, which is farther south than are the other Early Paleolithic sites in China. The average temperature in January is six degrees higher than that in Beijing today. Gongwangling is located on the south edge of the delta basin of the Fen and Wei rivers. In the first interglacial stage,

the Qinling Mountains and the Li Mountains were not as high as they are presently, so that some tropical and semi-tropical animals could have crossed over to the area of north Shaanxi (Liu, 1983).

The second reason has to do with the ecological zones inhabited by animals and the geological nature of the area. Gongwangling was in a region of semi-tropical forest that bordered the forest grasslands of north China in the Pleistocene. Therefore, the environment was suitable for semi-tropical animals, and the Gongwangling Fauna shows southern *Ailuropoda-Stegodon* characteristic of warm climates. Among the fossil mammals of the Lantian Man locality, 42 percent first appeared in the Middle Pleistocene and 37 percent represent modern species. *Loptobos*, which is usually found in the Lower Pleistocene period and occurs only once or twice in western Europe and South Asia as early as the Middle Pleistocene, is also found in the Gongwangling Fauna. It is, therefore, likely that the age of the Gongwangling Fauna is early Middle Pleistocene. Seventy percent of the Gongwangling Fauna species were found in Loc. 1 and Loc. 13 of Zhoukoudian, but 4 species became extinct before the time of Peking Man. Thus the Gongwangling Fauna is earlier than the fauna found in the Peking Man locality, but it is about the same age as the Djetis Fauna of *Homo erectus robustus*.

Stratigraphy

The Ba River passes through the center of Lantian county. Because the Li Mountains have risen continually since the late early Pliocene, the Ba River channel has moved toward the south, creating an imbalance in the height of the terraces that make up the banks of the river valley (Zhang, 1978). From Lantian to Xiehu, the terraces are well developed and wide. River deposits blending with sands, gravels, and loess formed the first and second terraces of the south bank of the Ba River in the Gongwang village area: the first terrace is 10-15 meters above the Ba River; the second terrace is about 25-45 meters above the Ba River. The Gongwangling hill is 450 m northwest of the Ba River (Fig. I 5).

The locality excavated in 1965 was on Gongwangling hill. The thickness of the stratum is 62.8 m. The stratum can be divided into nineteen layers. The skull of Lantian Man and associated fauna were found in the ninth layer. At the bottom of the stratum are two layers of sands and gravels: the top layer is about 11 m thick and contains quartzite, granite, and gneiss cobbles. The diameters of the cobblestones are from 5-10 cm to 1 m. The shape of the cobblestones is mostly oblate, and water-worn. There is little evidence of weathering. The lower layer is about 22 m thick and contains mainly granite, with some quartzite, and gneiss. Most of the gravels are much weathered, and not

well preserved. This layer was perhaps formed by an accumulation of earth and stones carried and finally deposited by a glacier. The top of the gravel layer is covered by 30 m of paleosoil, sometimes simply called reddish soil. The cultural remains were found 15-17 m above the gravel layer, together with the paleosoil and calcium nodules (the age of the cultural remains refers to the age of this calcium nodule formation). According to the original record, the human and animal fossils were in a single layer. This indicates that the locale was not a dwelling place or quarry. It might be a secondary deposit, most likely created by water. This deposit was not carried very far, however, because there is no wash polish or marking on the surfaces of the bones (Wu, 1966).

2. Description and Classification

Previous Work

The area of Lantian county occupies 2,400 sq. kilometers. Archaeologists have discovered 36 paleolithic localities in this area, 27 of which are Middle Pleistocene, 9 of which are Late Pleistocene. More than 600 artifacts were found in situ, over 200 of them from the Early Paleolithic period. Since 1963 several articles on the Early Paleolithic artifacts have been published (Wu, 1966; Huang, 1966; Dai, 1973; and Gai, 1976). Cores, flakes, scrapers, bifaces, choppers, picks, and spheroids are

described. The technologies used by the Lantian population are, as Dai notes "rather crude ... however, a certain degree of diversification may be noticed while the flakes and some retouched implements both point to the existence of a rather well defined manufacturing process" (Dai, 1973:12). Regardless of the classification used to describe the Lantian artifacts, we need a deeper understanding of the processes involved in their construction. That is why the next step will be what Jeffery Flenniken calls "replicative systems analysis" (Flenniken, 1989). In the present study, however, I focus upon two subsystems only: "selection of raw lithic material", and "reduction of lithic material into patterned tool forms", approaching these through the collection and knapping of the raw materials at the site.

The Collection

Over 200 stone artifacts from the Lantian area (27 localities) were *in situ*. I recorded 28 examples (from the localities of Gongwangling, Pingliang, Shijiangcun, Masigou, Ligou, and Guanludongcun) of the collection of the IVPP. (These 28 specimens comprised the total collection of the Lantian site in the IVPP.) (Table 1). Because of the nature of the collection, I do not have complete evidence concerning the *debitage* (there is one example of Debitage flake and one example of Debitage core in the study). It is difficult to say whether *debitage* was lost during

redeposition or during the excavation. Five of the artifacts show heavy edge damage, but most of the specimens are in fresh condition.

Core with single unifacial edge [C1] (9 specimens)

One made from sandstone cobble and eight from quartzite cobbles. The single edge is rough and uneven, but sharp. Most of the edges exhibit edge damage in varying degrees. Specimens P3857, P3847, P3850, and 3858 show heavy edge damage, resulting in small plunging scars on both faces (Figures I 5, I 6, and I 7). Specimens P3848 and P3466 show less edge damage, but there is pitting and pockmarks on the butt ends (Figures I 7 and I 8). Specimens P3849 and P3874 are comparatively smaller, and P3849 is a little rolled with one steeply trimmed edge (Fig. I 8). All the butt ends are formed by the rounded cortex surfaces of the cobbles. The length/breadth/thickness measurements range from 210x113x111 mm. to 82x79x35 mm., with an average of 146x114x81 mm. The weights range from 4,300 gm. to 100 gm., with an average of 1,844 gm.

Core with double unifacial edges [C2] (1 specimen)

This specimen (P3851) is made from a quartzite cobble. The original shape of the cobble was rectangular parallelogram. One longitudinal edge is made bifacially, and extends to the adjacent short edge. But the other

parallel longitudinal edge has only one flake removed. The cross-section is roughly plano-convex, because there is a convex surface on the back cortex. The length/breadth/thickness measurement is 186x154x103 mm. The weight is 3,000 gm. (Fig. I 9).

Core with unifacial distal end perpendicular to double edges [C3] (1 specimen)

This specimen, P3861 was made from a white quartzite block. The working edge is on the opposite extremity from the butt, and perpendicular to both lateral edges. The original shape of the block (straight-sided) is roughly square. One lateral edge was apparently made bifacially because the flaking on this lateral edge from the main working surface is too steep to produce a sharp edge. Flakes struck off from opposite directions, or bifacial flaking, made this edge sharper. The cross-section shows a rough lozenge shape. There is heavy edge damage present on three edges. The length/breadth/thickness measurement is 145x147x110 mm. The weight is 2,750 gm. (Fig. I 10).

Core with unifacial one end leaf-shaped [C5] (4 specimens)

These tools are made from quartzite cobbles. The butts consist of a rounded cortex surface. Examples P3878 and P3865 have two sharp trimmed edges, which converge biconvexly to a rounded point. Examples P2875 and P3864

have two steeply trimmed edges, which converge more directly to a point (there is a small piece of cortex on the point of example P3864). Although the shapes of the points in the examples are different, they are both leaf-shaped (Figures I 11 and I 12). Use traces are different for these specimens. Edge damage on P3878 is both on the lateral edges and point; on P3865 it is on the point; on P3864 it is only on a single lateral edge; and on P2875 it is on the double lateral edges only. The length/breadth/thickness measurements range from 188x184x109 mm. to 130x102x48 mm., with an average of 171x135x83 mm. The weights range from 3,000 gm. to 1,000 gm., with an average of 2,025 gm.

<u>Core with single bifacial edge [C9] (2 specimens)</u>

Example P3465 is made on a quartz cobble, and P3860 is made on a quartzite cobble. A single edge has been bifacially flaked on both. The flake scars are not very deep and have been removed alternately. P3465 is a small, rolled tool, with a relatively thick cross-section. The length/breadth/thickness measurement is 48x44x34 mm. The weight is 60 gm. P3860 is a well made small tool. The single edge makes up a large proportion of the circumference of the cobble (the edge/circumference ratio is 75 per cent. The edge is sharp and shows slight edge damage. The length/breadth/thickness measurement is 74x95x36 mm. The weight is 400 gm. (Fig. I 13).

Core with one end bifacial leaf-shape [C13] (1 specimen)

P3468 is made on an oblong quartize cobble specimen, bifacially flaked around the circumference except for a small area at the butt end. The central part of one lower face retains the cortex surface, the other face retains cortex only at the butt end. The double lateral edges are even and considerably blunt. The widest part of the tool is close to the butt and it is narrowed rapidly to the tip by trimming. The cross-section presents a bi-convex shape. The edge/circumference ratio is 80 per cent. The length/breadth/thickness measurements are 162x92x68 mm. The weight is 1,000 gm. (Fig. I 14).

Flake with single lateral unifacial edge [F1] (1 specimen)

P3871 is a thick quartize flake with only one lateral working edge, trimmed from ventral surface to dorsal. The edge is rough and uneven, it also shows edge damage. The bulb of percussion is not well defined. There is no cortex on the dorsal surface, so a prior flake must have been removed from this cobble, but there is cortex on the platform and the thick lateral surfaces. The distal edge is very thick, and broken straight across. The length/breadth/thickness measurements are 118x130x78 mm., the thickness and breadth of the platform are 22x61 mm. The

angle of the platform is 88 degrees. The weight is 800 gm. (Fig. I 15).

Flake with double lateral unifacial edges [F2] (1 specimen)

P3877 is a large quartize flake with two lateral working edges, the distal edge having been broken in antiquity (the color of the broken section is the same as that of the flaking scars). It is difficult to say what the original shape of the distal edge might have been. There are 3 or 4 deep flake scars on each lateral edge, which form several shallow notches, and the edges are blunt. Two trimming scars are on the back of the platform. The direction of flaking on platform and both lateral edges are from ventral surface to dorsal. The bulb of percussion is marked, and the cortex covers the center of the dorsal surface. The length/breadth/thickness measurements are 133x130x28 mm., the thickness and breadth of the platform are 25 and 72 mm. The angle of the platform is 111 degrees. The weight is 500 gm. (Fig. I 16).

Flake with unifacial leaf-shaped distal end [F5] (1 specimen)

P3467 is made on a large quartize flake, the distal tip of which is broken. The difference between this specimen and example P3877 is the position of the break. One can still see the original shape of P3467, which has been

trimmed from the ventral surface to the dorsal. There are large shallow flake scars on the dorsal surface and no remaining cortex. There is edge damage present on all edges. Some cortex remains on the platform, and the bulb of percussion is clearly marked. The length/breadth/thickness measurements are 171x122x40 mm., the thickness/breadth of the platform measurement is 48x124 mm. The angle of the platform is 118 degrees. The weight is 600 gm. (Fig. I 17).

<u>Flake with bifacial distal end perpendicular to double lateral edges [F14]</u> (1 specimen)

P3867 is a quartize flake with a perfectly straight platform indicating that it was taken off a piece of tabular material. Cortex is present only on the platform. The distal edge is rolled. The double lateral edges are steeply trimmed and also rolled. The flake scars and the bulb of percussion are not well marked. The length/breadth/thickness measurement is 62x84x34 mm., the thickness/breadth of the platform measurement is 12x92 mm; the angle of the platform is 129 degrees. The flake weighs 100 gm. (Fig. I 18).

<u>Unmodified flake [U1] (4 speciemns)</u>

These specimens show presence of edge damage on single, lateral, convex edges only. These edges are quite uneven, and some of them are blunt. P3873 and P3876 are quartzite,

whereas P3855 and P3856 are quartz. The bulbs of percussion and the angles of the striking platforms of these four specimens are variable. P3873 was made on a cobble; the bulb of percussion is marked, and the dorsal surface is cortex (Fig. I 18). P3876 was made from a large split flake with no cortex (Fig. I 19). The edge is heavily damaged and has 3 or 4 notches. P3855 was made from a small quartz pebble and was not heavily damaged. The cross-section of this flake is roughly triangular (Fig. I 20). P3856 was made from a subspheroid, and has a concave ventral surface. One flake was taken off prior to this one, so only half the dorsal surface is covered by cortex (Fig. I 20). The length/breadth/thickness measurement of P3873 is 112x76x24 mm.; of P3876 is 260x126x56 mm.; of P3855 is 32x49x21 mm.; of P3856 is 55x59x20 mm., with an average of 115x78x30 mm. The thickness/breadth measurement of P3873 is 18x60 mm.; of P3876 is 38x88 mm.; of P3855 is 21x50 mm; and P3856 is 32x56 mm., with an average of 27x64 mm. The angle of the striking platforms of P3873 is 102 degrees; for P3876, 120 degrees; for P3855, 101 degrees; and for P3856, 126 degrees with an average of 112 degrees. The weight of P3873 is 200 gm.; of P3876 is 1,700 gm.; of P3855 is 50 gm.; and of P3856 is 40 gm., with an average of 498 gm.

Debitage flake [D1] (1 specimen)

This complete flake (P3852) is made of quartzite, apparently produced while making a tool from a stone cobble. The distal tip is broken, and the only remaining cortex (about 7%) is on the platform. The length/breadth/thickness measurement is 54x38x8 mm. The thickness/breadth measurement is 8x35 mm. The angle of the striking platform is 97 degrees. The weight is 50 gm. (Fig. I 20).

Debitage core [D2] (1 specimen)

This complete and roughly spherical core (P3879) is made from a quartzite cobble. The entire surface is flaked except for a small area of cortex. A total of 7 flakes were removed from different directions around the entire circumference, and all exhibit sharp, fresh edges with no evidence of wear. The length/breadth/thickness measurement is 90x94x72 mm. The weight is 800 gm. (Fig. I 20).

3. Analysis and Replication

Technology

Materials selected by Lantian knappers include quartzite, quartz, and sandstone. These materials occur naturally in a variety of sizes and shapes. There are 19 core specimens in the collection. Dimensions of the core

tools (length/breadth/thickness) range from 210x113x111 mm. to 48x44x34 mm., with an average of 142x115x78 mm. These numbers indicate that for the lithic materials selected as raw material the breadth is similar to the length of the cobbles (the ratio is 1:1.2). There seems to be a relationship between rock type and size of the raw material, quartzite nodules being larger than quartz nodules. The shapes of the raw material blocks are quite regular, most of them being oblong, rectangular, or sub-round. The morphology of these pebbles, cobbles, and boulders indicates that most of them underwent water transportation.

Although there is some variation, 93 per cent of the collection (26 specimens) retain cortex, the greatest amount being 75%, and the least 0.04%, with an average of 46%. Numbers of flake scars on the core specimens range from 12 to 2, with an average of 6. These numbers indicate that the Lantian knappers were not using very complicated tool reduction sequences. There are 18 core tools in the study, 15 produced unifacially, and 3 (16.6%) with bifacial working edges. There is no clear patterning between the choice of size and shape of the raw material and the use of either bifacial or unifacial techniques. The weights of cores range from 4,300 gm. to 60 gm. with an average of 1,722 gm.

There are 9 flake specimens. The length/breadth/thickness measurements of the flakes range

from 260x126x56 mm., to 32x49x21 mm., with an average of 111x90x34 mm. The platform thickness ranges from 48 mm. to 8 mm. with an average of 24.8 mm., whereas platform breadth ranges from 124 mm. to 35 mm. with an average of 70.8 mm. The weights of flake specimens range from 1,700 gm. to 40 gm., with an average of 449 gm. There are two specimens with single flake scars on their platforms. The striking on the platform is from ventral surface to the dorsal, but the flaking on the cobble is from the dorsal surface to the ventral. These platform scars must have been created prior to removal of the flakes and indicate preparation of a platform angle less than 90 degrees. These two platforms were prepared by simple percussion.

The other seven flakes were struck from natural platforms, established at some location on the potential lithic material. Nearly all flakes are end-struck. On both flake tools and utilized flakes, the flaking scars - with one exception (P3867), which was flaked bifacially - are all on the dorsal surfaces. The platform angles range from 129 to 88 degrees with an average of 110 degrees. Platform angles on flakes indicate that these flakes were usually struck from cores at angles less than 90 degrees. The bulbs of percussion are marked, but not strongly protruding. Although there are several large flakes in the collection, none of them shows a flat, singly facetted platform at one end or through the middle of the cobble. Hence the on-anvil

or block-on-block technique was not used to produce any of these flakes. Specimens P3855 and P3856 were probably struck off the corners of large angular quartz cobbles by direct free-hand percussion. If not, then they must have been obtained by a bipolar technique, because they are too small to hold by hand and still provide a striking platform. It seems more likely that the most frequently used technique would have been direct free-hand percussion.

Selection of Raw Lithic Material

The first problem is size of the raw material. I follow contemporary geological practice in referring to pebbles, cobbles, and boulders (see Glossary). The artifacts from Lantian range from large pebbles to small boulders. For example, the longest specimen (P3876, Unmodified flake) is 260 mm. and the shortest tool, (P3465, Core with single bifacial edge) is 48 mm.. These figures indicate a wide variety of size selection and raw material use. This is partially because the lithic materials used by the Lantian people (quartzite, quartz, and sandstone gravels) are not difficult to find in the Lantian locality. Because the people did not have to carry or transport their lithic material far, they could readily select whatever sizes they needed.

There are two main sources of these lithic materials, and both are still accessible. One is the gravel stratum at

the Gongwangling hill, and the other is along the Ba River bed. The size, color, and quality of these lithic materials are similar, the only difference being that some of the raw material on the Ba River is too large to be transported by the river. Indeed, some of the boulders approach 2 m high. There are two sub-layers in the gravel stratum. The top one is not weathered, but the lower one is very weathered so there is a contrast in hardness between the two layers. Some of the weathered cobbles can be easily broken, like plaster. There is no perceptible difference in shape, color, and size between the weathered gravels and non-weathered ones, but there is a difference in weight, the weathered gravel being relatively lighter. The weathered gravels would not have been considered as knappable lithic materials by the Lantian people. The sizes of the boulders and cobbles selected range from 270x158x146 mm. to 90x80x60 mm. They are basically sub-rounded, oblong or oblate, some of them are more straight on one side, and form a right-angled triangle or rectangle (Fig. I 21). The average weight of gravel used was around 2,900 gm. The hammerstone I used the longest was a sandstone cobble that is very uniform in grain size and was not made up of layers. This hammerstone measured 130x76x55 mm, and weighed 1,560 gm. There are not many good hammerstones to use in this area. Either they break too easily (quartz), or they are too large

to hold. This might be the reason that not many hammerstones were found in the Lantian localities (Fig. 22).

Reduction Sequence

All replicated specimens were produced with hard hammer direct percussion. I did not change the size of the hammerstone with the different stages of production. Although it would have been possible to use two or three hammers of different sizes, I found it unnecessary. I began by removing one to four flakes from one side of the core, using my thigh to support it, to form a sharp edge (Fig. I 23). If the edge is not sharp enough after the first blows, it is possible to use this edge as the platform to continue striking in the same direction until a useable edge is formed (as on specimen P3848). Nine of the twenty-eight specimens are <u>Core with single unifacial edges [C1]</u>. The lithic materials I found best suited to produce these kinds of cores with single unifacial edges were of a particular shape. They usually had one side that was thinner than the other; some of them had triangular cross-section (P3466). Some of them had cylindrical cross-sections with the flake removal making one end sharp (as the specimen P3850) (Fig. I 24). With a wider and flat cobble, it is easier to remove flakes from two sides in order to get double unifacial working edges (P3851), or one end in leaf-shape with a tip (P3878, P3865) (Fig. I 25). To carry the process one step

further and obtain a sharp distal edge, one must direct some blows to the end opposite the butt end, and perpendicular to both lateral edges. This can provide the third working edge (Fig. I 26). It is quite easy to use a small quartz cobble to make a single bifacial edge tool. The flakes are removed alternately two or three times from each direction to form a rough "S"-shaped edge. This whole process takes only 2 to 3 minutes (see specimen P3465) (Fig. I 27). If the object is a core with bifacial one end leaf-shaped, it was then produced with the same techniques used for the single bifacial edge, but based on the oblong or oval shaped raw material. This kind of specimen is finally bifacially modified to obtain a leaf-shape at one end with a round butt that retains cortex at the other end (Figures I 28 and I 29).

By accident I broke a quartzite boulder (270x146x100 mm) with a small quartz cobble hammer using direct percussion with thigh support. The blow was struck at the middle of the side surface and the stone broke in half (Fig. I 30). This instance encouraged me to try to set the platform on the end of a boulder of the same size and to strike it in order to get an oblong shaped large flake. I then proceeded to retouch this flake from the ventral surface to dorsal on the double lateral edges to form a Flake with double lateral unifacial edges [F2] (as P3877); or on the lateral edge and distal edge to form a Flake with

a unifacial leaf-shaped distal end [F5] (as P3467). Although I did not break any boulders in half by striking them from the longer end, I was able to get some large flakes. Producing these flakes required heavy blows and a perfect angle. The striking platform will not be directly on the edge, but a rather wide 25-45 mm. margin from the edge (Fig. I 31). With the point of impact too close to the platform edge, a flake either too small or thin to be retouched is produced, so the technique requires exact tolerances. If the point of impact is not just right, the process will fail. In general, it is not necessary to prepare a platform for flaking. The selected raw material usually provides an angle less than 90 degrees to begin knapping. By comparison, it is easier to obtain small flakes by reduction from a core tool than to break raw material for large useable flakes. Because quartzite is an extremely hard substance, producing a large flake also requires a very strong blow.

Chapter 3 Liangshan

In July 1951, Yu Shiyuan of the Department of Geology of Northwest University, Xi'an, found some paleolithic artifacts in the Liangshan area of Shaanxi province. These artifacts constituted the first discovery and the earliest evidence of human activity in the Hanshui River valley. By 1980, Yan Jiaqi of Xi'an Mining College had collected about 1,000 artifacts around the Longgangsi site. According to the geomorphology, the artifacts came from the third terrace of the Hanshui River. Therefore, Yan suggested that the Longgangsi artifacts belong to the Paleolithic period with a geologic age ranging from Middle to Late Pleistocene.

In 1982, Huang Weiwen of the IVPP found about 30 stone artifacts in surplus gravel from the quarry of the Longgangsi brick kiln, which is on the third terrace. Two of these stone artifacts were obtained from a stratum in the quarry. Since then, the Archaeological Institute of Shaanxi Province has collected artifacts from 17 more localities in the Liangshan area: Wuhoumu, Yuanshan, Huangsha, Hunjiagou, Jinzhai, Jinquansi, Wudaogou, and Sujiashan of Mianxian county; Gushan of Hanzhong city; Tudiling, Huanglongsigada, Yingpanliang, Chanjiagou, Nanzhai, and Liangxi of Nanzheng county; and Baoshan and Lujiapo of Chenggu county. The subsequent investigation was wide ranging: 10 km east to west, and 2 km south to north. A small excavation in the

gravel layer of the third terrace, east of Longgangsi was also carried out. Although there is no detailed report on this excavation, the investigators say that they found some artifacts that resemble those collected from the surface. The total number of artifacts from the investigations of Huang and the Shaanxi Archaeological Institute is somewhat over 800 specimens.

In the autumn of 1985, a field team from the IVPP and the Geological Museum of Shaanxi Province found 10 more sites in the Liangshan area (Wenquan, Chituling, Yangjiawan, and Hujiadu in Mianxian county; Chengdingcun, Diheba of Chenggu county; and Dabagou, Yangzheng, Jinshui, and Balong of Yangxian county). This field team reported that about 200 paleoliths were found in the sediments of the third terrace, a terrace that was made up of yellow-reddish sandy clay with concretions and some mammalian fossils. These investigators came to the conclusion that "the fossils associated with the Paleoliths belong to the *Ailuropoda-Stegodon* fauna, so that the Paleolithic age can be attributed to Middle Pleistocene" (Tang 1987). Although these mammalian fossils were not found at the Longgangsi brick kiln site, they were found on the third terrace of other areas of the Hanshui River. This discovery can help us make further determinations about the age of the site.

1. Geological and Archaeological Background

Location

The Liangshan site is named for the Liangshan Mountains. The site is situated in the quarry of the Longgangsi brick kiln (the site was exposed by the quarry workers), about 10 km southwest of Hanzhong city (Fig. II 1). It is 106.58 degrees east longitude, 33.3 degrees north latitude. The Liangshan site is in the upper reaches of the Hanshui River, and in the southern margin of the Hanzhong Basin (the basin is 510-530 m above sea level). The Qinling Mountains are on the northern margin of the Hanzhong Basin. Liangshan is an extension of Daba Mountain. The highest peak of the Liangshan Mountains is near upper Liangshan village, which is 1,021.4 m above sea level. The Liangshan mountains slope gradually downward toward the southeast, and the Longgangsi brick kiln is situated on the tail of the mountain, 540 m above sea level.

The Hanshui River is the largest tributary of the Yangtze river. It is 1,500 km long, and its drainage area is about 174,000 square kilometers. The Hanzhong Basin is on the upper part of the Hanshui River and contains some 100 km of the Hanshui River's course (Fig. II 2). According to Shen Yuchang (Shen, 1956), there are five terrace levels in

the Longgangsi region (artifacts and mammalian faunas were found on the third terrace):

1. A flood plain less than 10 m above the river bed.
2. An alluvial terrace 10-15 m above the river bed.
3. A red clay terrace 30-40 m above the river bed.
4. A compound terrace 70-80 m above the river bed.
5. A fifth terrace 150-200 m above the river bed.

Shen Yuchang suggests that the red clay terrace was probably formed by a change of climate.

Mammalian Fauna

Mammalian fauna were found at the Nijiaxi site, about 2 km north of Dabagou village in Yang county. The sediments of the third terrace here consist of yellow-reddish sandy clay (sometimes called red clay) with concretions, which is 0.5-1.0 m. thick. The mammalian fossils found in association with the Paleoliths include *Ailuropoda melanoleuca, Ursus sp., Stegodon orientalis, Rhinoceros sinensis, Sus sp., Muntiacus muntiak, Rusa sp., Gazella sp., Bubalus sp. etc.* These are the dominant species in the south of China and the southern part of Asia during the Middle and Late Pleistocene. The authors also noted that some fauna were found in the lower layer of the Jinshuihekou locality, a layer that belongs to the Early Pleistocene period. These are *Ailuropoda microta, Canis sp., Ursus sp., Stegodon sp.,*

Rhinoceros sinensis, Nestoritherium sp., Rusa sp. nov., Gazella sp., and *Bubalus sp.* The stratum of *Ailuropoda-Stegodon* fauna is directly above the Early Pleistocene stratum, therefore the *Ailuropoda-Stegodon* fauna probably belong to the Middle Pleistocene (Yang 1987).

Stratigraphy

The stratigraphy of the Longgangsi locality is 8-10 m thick and the sequence of the sections from top to bottom is as follows (Fig. II 3):

1. Brownish red, brownish gray clay, 0.2-0.5 m. thick.
2. Grayish drab fine sand, thickness 0.2 m.
3. Blackish drab clay, thickness 0.2-0.3 m.
4. Reddish drab sandy clay, thickness 2-8 m.
5. Gravel dispersed throughout a 1-2 m thick stratum of sandy clay.
6. Grayish brown, grayish green crystalline complex, which comprises the bottom of the third terrace; local exposed thickness 2-3 m.

More than 200 artifacts and artifact fragments were obtained from layer 5 *in situ*. Comparing these artifacts to the ones collected from the surface of the fourth and fifth terrace levels of other localities in the Liangshan region, one finds that the two are very similar in types, techniques, sizes, and raw materials. This similarity also

holds true for the artifacts of the Liangshan area as a whole.

2. Description and Classification

Previous Work

From 1951 to the present the total area investigated amounts to 900 sq. kilometers. There are 28 paleolithic localities in this area, and all are on the third terrace of the Hanshui River, or on the contour line level of tributaries of the Hanshui River. The sediments of the third terrace are yellow-reddish sandy clay usually 3-5 m. thick. In some places this clay can reach a thickness of 10 m, but the elevation of the layer is very stable everywhere, generally about 520-600 m. above sea level. The field team of the IVPP and the geological team of Shaanxi Province found fossils associated with the Paleoliths in the sediments of the third terrace. These fossils belong to the *Ailuropoda-Stegodon* fauna, which means that the Liangshan locations can be attributed to the Middle Pleistocene.

The first reports on this area were written by Yan Jiaqi in 1980. Since that time several other articles have been published: Yan, 1981, 1983, 1988; Hanshui Archaeological Team of Shaanxi Province Archaeological Institute, 1985; Tang, 1987; and Huang, 1987. The tool types are described as chopper-chopping, spheroid, biface, cleaver, pick, and scraper. They are made from quartzite

(dark with stripes), quartz (white), and volcanic (dark and light gray) materials. Yan suggests that there is a definite relationship between the tool types and selection of the raw material. He notes that over 95% of the spheroids are made of quartz, over 95% of the chopper-chopping tools from quartzite, and over 95% of the scrapers are quartz and volcanic rock (Yan 1983). Huang thinks the artifacts of the Liangshan area fall mainly in the category of heavy-duty tools, but that there are also a small number of light-duty tools. According to Tang's study, the diameters of the spheroids range from 11 cm. to 7 cm., the weights range from 1,600 gm. to 250 gm.. These numbers also indicate that the tools are biased toward the larger, heavy-duty type. Most Chinese scholars think that in typology, technology and size, the Liangshan stone industry is very similar to that from Lantian. The technology employed for the Liangshan industry was direct, free-hand percussion, using "bipolar" and block-on-block techniques. However, until my preliminary work, no experimental flintknapping had been done to provide evidence for distinguishing among these three technologies in the Liangshan area.

The Collection

I recorded 91 examples of stone artifacts from the collection of the IVPP and Shaanxi Province Archaeological Institute (Table 2). While there are roughly 2,000

specimens in the collections, these 91 examples are approximately 30% of those recovered from surface collections and excavations, and were considered representive of the total collection by the IVPP and Shaanxi Archaeological Institute. These 91 were all I was given permission to study. Eighty-one of the specimens are from the collection of IVPP (from the 1982 excavation in the Longgangsi brick kiln, and the 1985 investigation), ten are from the Shaanxi Archaeological Institute (from Chitulin, Longgangsi, Nanzhen, Mianyuan, Nanlongyou, Mianxian, Mianhuangsha, and Yangwangdong 008 localities). Most of the specimens are in fresh condition (they are not rolled and the trimming scars are clearly visible).

Core with single unifacial edge [C1] (15 specimens)

Three of these were made from volcanic cobbles, five from quartzite cobbles and seven from quartz cobbles. There is edge damage present only on the single unifacial edge of some specimens (see specimens P6303, P6307, P6269, P6300, P6250, and P6253), present only on the proximal surface of some specimens (specimens P6293, P6262, P6304, and P6263), and heavily present both on the single edge, point, and proximal surface of other specimens (specimens P6292, P6287, P6267 and SPB Chitulin 85004). Specimen Chitulin 2 has damage on the point only, one side of the point being formed

by the single unifacial edge. There are steeply trimmed multiple scars on this edge (Figures II 4).

There is not much relationship between the location of the edge damage and the shape of the artifact. For example, the shape and size of specimens P6307 and P6262 are similar, but the location of the edge damage is very different. P6307 was damaged on the single working edge (Fig. II 5), but P6262 was damaged only on the proximal surface of the core (Fig. II 8). Most of the unifacial single edge specimens are formed on the longer ends of elliptical cobbles (P6293, P6303, P6304, P6287, and SBP Chitulin 85004 in Figures II 4 to II 7). Yet some of the single edge specimens are formed along the length of the elliptical cobbles, such as specimen P6292 (Fig. II 8). The length/breadth/thickness measurements range from 208x116x90 mm. to 68x46x43 mm., with an average of 135x100x67 mm. The weights range from 3,300 gm. to 100 gm., with an average of 1,064 gm.

<u>Core with double unifacial edges [C2] (4 specimens)</u>

Specimen P6210 is made from a large half block of volcanic cobble. The broken face is flat with no signs of having been worked. The cross-section is a trilateral with a longitudinal dorsal ridge formed by the intersection of the trimming scars on both lateral edges. The butt end retains a small portion of cortex. The tip is pointed, but

on one side of the point partial cortex remains. There is edge damage present on the frontal part of the tool (Fig. II 9). The length/breadth/thickness measurement is 148x74x57 mm. The weight is 800 gm. Specimen P6311 is made from a thick volcanic block. On the top of the previously flaked surface, there is a mass of flake scars from the reverse direction on both lateral edges. The specimen has sharp edges, slightly damaged, but these are not even and the tool is of an irregular ovate shape. The length/breadth/thickness measurement is 113x82x52 mm. The weight is 500 gm. (Fig. II 9). Specimen Liangshan 85.11 is made from a quartzite cobble. The tool is square with double unifacial edges that meet at the corner of two edges. The edges are steeply trimmed, and there is some pitting and pockmarking present on the cortex surface. The length/breadth/thickness measurement is 85x79x43 mm, the weight is 500 gm. (Fig. II 9). Specimen P6302 is also made from a large volcanic cobble, the tip was broken and damaged. The lower surface of the cobble is quite flat and was used as the platform. There are three shallow flaking scars on one lateral edge, which are opposed to a single deep scar on the other lateral edge; both lateral edges show edge damage. The butt end retains a large area of cortex. The length/breadth/thickness measurement is 156x104x63 mm. The weight is 1,800 gm. (Fig. II 9).

Core with one unifacial leaf-shaped end [C5] (1 specimen)

Chitulin 3 is made from a volcanic cobble. The tool is oblong with a sharp, leaf-shaped tip. The flake scars at the tip are large and shallow. The butt is relatively massive, and retains cortex. Because there is a protruding surface on the back of the tool, the cross-sectone is quite thick. There is damage present at the tip, sides, and butt. The length/breadth/thickness measurement is 179x119x99 mm. The weight is 2,000 gm. (Fig. 10).

Core with all unifacial edges [C7] (2 specimens)

Specimen P6214 was made on a small square quartzite cobble, and specimen Liangshan 85.14 was made on an ovate volcanic cobble. P6214 shows all the multiple flaking on one face only; Liangshan 85.14 has most of flaking scars on one face, but also has two flake scars on the obverse face. These two flake scars on the obverse face show that the tool maker used the reverse unflaked surface as the platform, so when viewed as a whole, the edge of the circumference is seen to be flaked entirely unifacially (Fig. II 11). Although there is a small cortex on the edge of P6214, this does not affect the type of the tool (Fig. 11). These two specimens show heavy edge damage on all the edges. The length/breadth/thickness measurement of P6214 is 86x84x60 mm.; for Liangshan 85.14 it is 123x106x60 mm. The weight of P6214 is 500 gm., and Liangshan 85.14 is 800 gm.

Core with single bifacial edge [C9] (16 specimens)

Specimens P6305 and P6260 are made on quartzite cobbles. Specimens P6217, P6227, P6266, and P6285 are made on volcanic cobbles. The other 10 specimens are made from quartz cobbles and pebbles. The single bifacial edge of five specimens is on the side of the cobble, most of them have been trimmed over 50 per cent of the circumference. The single bifacial edge of 11 specimens is on the end of ovate cobble, and most of them are trimmed for less than 50 per cent of the circumference. P6221, P6286, and P6224 are small, rolled tools (Fig. II 12). The single bifacial edge on specimens P6225 and P6305 is even, and the flaking scars are relatively shallow (Figures II 15 and II 12). The remainder of the edges are generally jagged and exhibit edge damage. The length/breadth/thickness measurements range from 123x126x47 mm. to 48x42x28 mm, with an average of 99x93x63 mm. The weights range from 2,000 gm. to 80 gm., with an average of 724 gm. (Figures II 12 to II 18).

Core with one bifacial end perpendicular to double lateral edges [C11] (1 specimen)

Specimen P6222 is made on an oblong volcanic cobble. The butt is formed by cortex on the long side of the cobble. The double lateral edges and transverse edge are bifacial, with multiple scars on both surfaces. The transverse edge

is almost straight and perpendicular to the double edges. The edges are sharp, damaged, and somewhat jagged. The flake scars are relatively stepped on the edges, the specimen is thick in cross-section. The length/breadth/thickness measurement is 89x54x59 mm. The weight is 100 gm (Fig. II 19).

Core with one bifacial leaf-shaped end [C13] (11 specimens)

Specimens Mianxian 002 and 86 Mianyuan 014 were made on quartzite cobbles. Specimens 86 Mianyuan 005 and SBP Chitulin 85002 were made on quartz cobbles. The other 7 specimens were made on volcanic cobbles. Specimens P6313 (Fig. II 20), SBP Chitulin 85002 (Fig. II 19), and 85 Nanzhen 003 were made on short, stumpy cobbles. About half of the circumferences of these specimens is bifacially flaked with some large and shallow scars. The other half of each specimen's circumference is a round butt with remaining cortex. Specimen 85 Nanzhen 003 is more pointed than the others (Fig. II 21). Specimen 86 Mianyuan 004 was made on a large, crude, oblong cobble. The edge is jagged with some presence of edge damage, and the butt shows pitting and pockmarking (Fig. II 21). The 4 specimens above all have cortex in the central and butt end of both surfaces. The other specimens are formed by flaking scars on one face, the upper face, with a cortex surface running down from the central area to the butt. The opposite face, or lower face

is either a natural fracture, or is bifacially trimmed. This trimming extends round the butt. The lower faces of specimens Nanlongyou 002 and 86 Mianyuan 014 are formed by bifacial trimming, which meets the natural fracture. The tips are wide, and the edges are jagged (Fig. II 23). The lower faces of specimens Liangshan 0005 (Fig. II 22), Mianxian 002 (Fig. II 22), 86 Mianyuan 005 (Fig. II 24), 86 Mianhuangsha 001 (Fig. II 25) , and Longgangsi P6211 (Fig. II 25) are all formed by bifacial trimming. This trimming extends around the butt end. The flake scars on the lateral edges of the two faces do not run evenly. There is edge damage, or pitting and pockmarking heavily present on the butt ends (9 specimens), points (2 specimens), or double edge (1 specimen). Most of these specimens exhibit damage on more than one edge or surface. The length/breadth/thickness measurements range from 209x92x70 mm. to 112x108x81 mm., with an average of 164x102x73 mm. The weights range from 1,500 gm. to 300 gm., with an average of 982 gm.

Core with all bifacial edges [C15] (3 specimens)

Specimen 82 Liangshan P6218 was made on a small quartz cobble. Ninety per cent of the circumference is flaked bifacially. There is a small area of cortex on the central portion of both faces. The cross-section is relatively thick, and biconvex. The edge of the tool is rolled. The

length/breadth/thickness measurement is 90x80x60 mm. The weight is 300 gm. (Fig. II 26). Specimen 85 Liangshan P6289 and 82 Longgangsi P6312 are made of ovate quartzite. P6289 retains a larger area of the cortex than P6312. The edges of the two specimens are sharp, jagged, and fresh. There are large shallow flake scars on both faces. The cross-sections of these tools are plano-convex. The length/breadth/thickness measurement of P6289 is 97x78x44 mm.; P6312 is 127x102x68 mm. The weight of P6289 is 200 gm.; P6312 is 1,000 gm.(Fig. II 26).

<u>Core tools in other shapes [C17] (8 specimens)</u>

The general forms of these kinds of tools are somewhat irregular and the tools are only approximately spheroid. Specimen P6289 is made on a thick volcanic cobble. Steep flakes have been taken from different directions off the cobble so that it is sufficiently well-rounded to be classed as a stone ball. The length/breadth/thickness measurement is 78x78x76 mm. (Fig. II 27). Specimens P6232 and P6208 are made on quartzite cobbles. These specimens are also formed by steep flaking (Fig. II 27). On P6232 one flat cortex surface of the cobble was used as the platform from which to take the flakes; the platform of P6208 was made by flaking from one direction, then using this platform to trim the specimen vertically into a sub-spheroid. The other 5 specimens were made on quartz cobbles and one pebble. The

edges are made by flaking from different directions. These specimens are rolled. The surfaces of most of the specimens have been extensively damaged (Figures II 27 and II 28). The length/breadth/thickness measurements range from 103x100x105 mm. to 63x63x71 mm., with an average of 83x74x78 mm. The weights range from 1,500 gm. to 100 gm., with an average of 688 gm.

Flake with single lateral unifacial edge [F1] (2 specimens)

Both specimens are made from volcanic flakes. Liangshan 85.19 is a long, narrow, thick flake tool. The single edge is made from ventral surface to dorsal by two flakes struck off at a very steep angle. The platform and other lateral areas retain cortex. The length/breadth/thickness measurements are 146x75x53 mm., the thickness and breadth of the platform is 43x60.5 mm., and the angle of the platform is 122 degrees. The weight is 600 gm. (Fig. II 29).

Specimen 85 Liangshan P6301 is a relatively wide, thin flake tool. The single edge is also made from ventral surface to dorsal. There are two flaking scars on the platform, which are also made from ventral to dorsal surface. The cortex remains on the dorsal surface only. The single edge and distal edge of these specimens are uneven and exhibit edge damage. The length/breadth/thickness measurements are 118x88x34 mm, the

thickness and breadth of the platform is 85 degrees. The weight is 300 gm. (Fig. II 29).

Flake with double lateral unifacial edges [F2] (2 specimens)

Specimen 85 Liangshan P6243 was made from a small quartzite flake. There are two flake scars on the dorsal surface from previous work. The tool is flaked from dorsal surface to ventral. There is no cortex. The length/breadth/thickness measurements are 48x28x9 mm, the thickness and breadth of the platform is 4x7 mm. The angle of the platform is 90 degrees (Fig. II 29).

Specimen P6277 was made from a thin volcanic whole flake. The ventral surface is curved, and there is a longitudinal dorsal crest. There is a small part of the cortex remaining on the side of the distal end. There is a flake scar on the platform, which was made at the same time as the flaking scars on the double lateral edges. The bulb of percussion is not well marked. There is edge damage present on both lateral and the distal edges. The length/breadth/thickness measurements are 79x47x16 mm, the thickness and breadth of the platform is 7x17 mm. The angle of the platform is 127 degrees. The weight is 40 gm. (Fig. II 29).

Flake with unifacial leaf-shaped distal end [F5] (1 specimen)

Specimen 85 Liangshan P6257 was made on a thick volcanic flake. The platform and most of the area on the dorsal surface retain the cortex. The bulb of percussion is well marked. Retouch is present on the dorsal face, and varies from steep to shallow. The tip of the tool is a broad point. There is edge damage present on the distal edge. The length/breadth/thickness measurements are 130x122x59 mm, the thickness and breadth of the platform are 40x98 mm. The angle of the platform is 122 degrees. The weight is 1,400 gm. (Fig. II 29).

<u>Flake with unifacial distal end [F7] (1 specimen)</u>

Specimen ND 008 is made on a whole quartzite flake whose breadth is greater than its length. The cortex is retained on the platform and dorsal face. The trimming scars are on the distal end of the ventral face. The edge is sharp, and there is edge damage present on it. The bulb of percussion is marked. The length/breadth/thickness measurements are 110x144x67 mm., the thickness and breadth of the platform are 70x62 mm. The angle of the platform is 125 degrees. The weight is 700 gm. (Fig. 30).

<u>Flake with unifacial proximal end [F8] (1 specimens)</u>

Specimen P6275 is made on a nearly round quartz flake. The platform has been almost entirely removed by trimming from ventral face to dorsal. There are two large shallow

flake scars on the proximal end, and two small steep scars on the lateral edge. There is edge damage present on the distal edge. The profile of the flake is curved towards the ventral face. The length/breadth/thickness measurements are 76x74x26 mm, the thickness and breadth of the platform are 16x25 mm. The angle of the platform is 91 degrees. The weight is 45 gm. (Fig. II 30).

Flake with unifacial distal and proximal ends [F9] (3 specimens)

These three specimens are all trimmed on both the distal and proximal edges of the flakes. The direction of the trimming is from the ventral face to the dorsal. There are various areas of the cortex remaining on the dorsal face of each specimen. The platforms of specimens P6246 and Liangshan 85.8 are almost gone, and there is no information about the original angles of the platforms. P6246 is made on a length > breadth quartzite flake. There is edge damage present on the distal, proximal, and one of the lateral edges. The length/breadth/thickness measurements are 131x99x34 mm. The thickness and breadth of the platform is 28x60 mm. The weight is 200 gm (Fig. II 30).

Specimens Liangshan 85.6 and Liangshan 85.8 are made on breadth > length flakes, the first on a quartz flake with presence of edge damage on the distal and proximal edges. The other is made on a volcanic flake with edge damage on

the distal edge only. The length/breadth/thickness measurements of Liangshan 85.6 are 67x92x26 mm., Liangshan 85.8 are 38x54x20 mm. The thickness and breadth of the platform of Liangshan 85.6 are 16x86 mm., Liangshan 85.8 are 1x36 mm. The weight of Liangshan 85.6 is 50 gm. and Liangshan 85.8 is 30 gm. The angle of the platform of Liangshan 85.6 is 137 degrees (Fig. II 30).

Flake with single lateral bifacial edge [F12] (4 specimens)

Specimen 85 Liangshan P6281 was made on a small quartz flake. Specimens P6216, P6274, and Liangshan 85.10 were made on volcanic flakes. P6215 is a flake of breadth > length. There are flake scars on both the lateral and distal edges on the ventral face, but there is only bifacial trimming on one lateral edge on the dorsal face. There is edge damage present on these three edges. The length/breadth/thickness measurements are 72x100x45 mm., the thickness and breadth of the platform is 38x80 mm. The angle of the platform is 90 degrees. The weight is 200 gm. Both lateral edges of specimen P6281 are trimmed, but only one of them is trimmed bifacially. There is edge damage present on this bifacial single edge. The length/breadth/thickness measuremens are 60x34x22 mm., the thickness and breadth of the platform is 6x10 mm. The angle of the platform is 90 degrees. The weight is 50 gm. There is a flake scar on the platform of specimen P6274, which is

made from ventral face to dorsal. The single lateral edge is made bifacially. There is cortex partially covering the platform and dorsal face. The length/breadth/thickness measurements are 81x72x44 mm., the thickness and breadth are 26x48 mm. The angle of the platform is 145 degrees. The weight is 200 gm. Specimen Liangshan 85.10 is a roughly rectangular flake. There is cortex on both the platform and distal edges. The previous flake scars form a convex cone in the center of the dorsal face. The bulb of percussion is well marked. There is edge damage present on one lateral edge that is trimmed bifacially (the other edge is trimmed unifacially). The length/breadth/thickness measurements are 84x78x32 mm., the thickness and breadth are 43x33 mm. The angle of the platform is 120 degrees. The weight is 200 gm. (Fig. II 31).

Flake with double lateral bifacial edges [F13] (1 specimen)

Specimen P6271 is made on a thick quartz flake. The double lateral edges are formed bifacially. There is edge damage present on the distal edge. There is a small area of the cortex on the platform only. The length/breadth/thickness measurements are 76x70x32 mm, the thickness and breadth of the platform are 32x55 mm. The angle of the platform is 128 degrees. The weight is 100 gm. (Fig. II 32).

Flake with bifacial distal end perpendicular to double lateral edges [F14] (2 specimens)

Specimens P6270 and P6280 are both made on breadth >length quartz flakes. The platform and one lateral edge of P6270 retain cortex, the other lateral edge and distal edge are made bifacially. Both lateral edges and distal edges of P6280 are made bifacially. There is a single flake scar on the platform, which was struck from ventral face to dorsal. There is edge damage present on the double lateral edges and distal edge of both specimens. The length/breadth/thickness measurements of P6270 are 69x84x34 mm., and P6280 are 32x62x18 mm. The thickness and breadth of the platform of P6270 is 32x56 mm., and P6280 is 19x44 mm. The angle of the platform of P6270 is 125 degrees; P6280 is 92 degrees. The weight of P6270 is 200 gm. and P6280 is 35 gm. (Fig. II 32).

Flake with bifacial distal end [F18] (1 specimen)

Specimen Liangshan 85.7 was made on a breadth > length volcanic flake. The distal edge is made bifacially and exhibits edge damage. There is a flake scar on the platform, struck from ventral face to dorsal. Most of the platform and lateral sides retain the cortex. The length/breadth/thickness measurements are 76x110x33 mm., the thickness and breadth of the platform is 26x102 mm. The angle of the platform is 115 degrees. The weight is 100 gm. (Fig. II 32).

Flake with all bifacial edges [F21] (1 specimen)

Specimen 85 Liangshan P6279 was made on an approximately round quartz flake. The tool is rolled. Flake scars cover both faces of the flake except for a small area of the cortex on the dorsal face. There is edge damage present on all the edges. The length/breadth/thickness measurements are 57x52x30 mm., the thickness and breadth of the platform is 14x30 mm., the angle of the platform is 72 degrees. The weight is 40 gm. (Fig. II 21).

Unmodified flake [U1] (9 specimens)

Specimens P6245, Liangshan 85.5, and Liangshan 85.3 were made on volcanic flakes. Specimens Liangshan 85.9 and P6282 were made on small quartz flakes. Specimens P6248, P6247, P6229, and P6228 were made on quartzite flakes. Except for specimens P6228 and Liangshan 85.3, which are damaged by natural causes or by use (both tools are broken straight down from the platform to the distal edge), all the flakes are complete. There is cortex on the platform and dorsal face of each specimen, and usually there is a relatively thick platform with a well marked bulb of percussion and sharp natural distal edge. Within this entire group of tools (U1), only specimens P6248 and P6229 have lengths greater than breadths, the rest of them are all broader than long. There are flake scars on the dorsal

faces of specimens P6245, P6248, P6229, and P6228, but most of them are results of previous work. The edge damage present on these specimens is basically on the distal and one lateral edges. Most of these edges are jagged, as on specimen Liangshan 85.5. There is edge damage present on the lateral edges or distal edge of all the specimens (see specimen P6247, Fig. II 33). The length/breadth/thickness measurements range from 132x128x62 mm. to 25x42x12 mm., with an average of 85x88x32 mm. The thickness and breadth ranges from 65x125 mm. to 1x18 mm., with an average of 26x70 mm. The angles of the platforms range from 130 to 0 degrees, with an average of 86 degrees. The weight range is from 1,100 to 10 gm., with an average of 287 gm. (Figures II 33 to II 35).

Debitage core [D2] (2 specimen)

Specimen P6309 was made on an almost round volcanic cobble. There is pitting and pockmarks on the surface. The three flake scars are trimmed from different directions on the surface, the rest of the surface still retains cortex. The length/breadth/thickness measurements are 62x58x45 mm., the weight is 100 gm. (Fig. II 36).

Specimen Yangwangdong 008 was made on a roughly rectangular volcanic cobble. There are five elongated flake scars with parallel edges on one side of the core; the other side is still covered with cortex. These flakes are all

taken from a flat upper face of the core, which was used as the platform. But the original platform was struck off by the removal of two parallel flakes from the side of the future striking platform which was the edge of the upper surface. One-third of the circumference of the upper surface retains the cortex. The length/breadth/thickness measurements are 100x92x84 mm. The weight is 400 gm. (Fig. II 36).

3. Analysis and Replication

Technology

An overview of the raw material used for the 91 artifacts in the collection indicates that there are 35 specimens of volcanic rock, 34 specimens of quartzite, and 22 of quartz. Dimensions of the core tools (length/breadth/thickness) range from 256x109x72 mm. to 48x42x28 mm., with an average of 117x91x66 mm. These numbers provide evidence that the raw materials were selected in a variety of sizes and shapes. They are usually water-worn pebbles, cobbles, and boulders. Most of these weathered nodules and angular fragments are oblong, rectangular, or sub-round.

Ninety-seven per cent of the specimens retain cortex, the greatest amount covered with cortex being 88.8 per cent and the least being 7.7 per cent, with an average of 46 per cent. Numbers of flake scars on the core specimens range

from 19 to 2, with an average of 7. There are 61 core tools in the study, 31 (51%) of them were produced bifacially, 22 (36%) of them have unifacial working edges. Another 8 core tools were flaked from different directions in order to form an approximately spheroid shape. There is no clear patterning in the choice of size and shape of the raw material and the use of either bifacial or unifacial techniques. For example, the average dimension (length/breadth/thickness) of the Core with single unifacial edge is 135x100x67 mm., and that of the Core with single bifacial edge is 99x93x63 mm. These bifacially edged tools seem somewhat smaller than the unifacially edged tools. But in another example, the average demensions of the Core with one unifacial leaf-shaped edge is 179x119x99 mm., while the Core with bifacial leaf-shaped edge is 164x102x73 mm. These two average dimension numbers are not much different. The weight of core specimens range from 3,300 gm. to 80 gm., with an average of 805 gm.

There are 28 flake specimens in the study: 10 were produced unifacially, 9 have bifacial working edges, and the other 9 are utilized flakes. The length/breadth/thickness measurements range from 110x144x67 mm. to 25x42x12 mm., with an average of 83x81x33 mm. Platform thickness ranges from 65 mm. to 1 mm. with an average of 25.5 mm., whereas platform breadth ranges from 125 mm. to 7 mm. with an average of 60 mm.. There are 16 (57%) flake tools with

cortex on the platform, 9 (32%) of the flake tools have platforms retaining 1 to 2 flake scars. On 3 others natural fracture surfaces were used as platforms. There are no signs of platform preparation; at least 90% of the flake scars on the platforms were made at the same time as the flaking scars on the working edges. Among 10 unifacial flake tools, 8 (80%) of the working edges were made from ventral surface to dorsal, only 2 specimens (20%) have working edges knapped from dorsal surface to ventral. The platform angles range from 145 to 63 degrees with an average of 110 degrees (this does not include those with no remaining platform). The platform angles on flake tools indicate that these flakes were usually struck from cores at angles averaging about 70 degrees. The bulbs of percussion are marked, but differ according to the raw material. For example, volcanic flakes usually show more clearly marked bulbs of percussion than does quartz. The marks of percussion indicate that the most frequently used technique in the Liangshan area was direct free-hand percussion. The weight of flake specimens range from 1,400 gm. to 25 gm., with an average of 253 gm. There were 8 approximately spherical specimens (9%) that are extensively battered by use. These are perhaps hammerstones. The weights of these hammerstones average 688 gm., and the core tools averaged 805 gm.

There are 12 flake specimens (43%) in which the breadth is greater than the length. Some of these have wide flat platforms, such as Liangshan P6245, which shows two bulbs of percussion on the proximal edge. These adjacent bulbs of percussion on the platform suggest that the block-on-block technique might have been used to produce some of these flakes.

Specimen Yangwangdong 008 [D2] shows a technique not paralleled elsewhere in the study collections. There are five elongated flake scars with parallel edges on one side of the core. The original platform was struck off by the removal of two parallel flakes from the edge of the upper surface. The butt of the core is almost flat. The shape and flake scars on this core are very similar to a Levallois core, yet no Levallois flakes or other elongated flakes are present in the collection.

Selection of Raw Lithic Material

There is gravel on the second, third, fourth, and fifth terraces of the Hanshi River. Using the data provided by the original excavation report of the Longgangsi area, we see the following differences in the gravels (Huang, 1987):

Terrace	Diameter
Second	6 cm
Third	10-12 cm
Fourth	5-6 cm

Fifth 3-4 cm

These data indicate that 10-12 cm should be an appropriate measure for the average dimension of Liangshan area specimens. The thickness of the gravel layer in the third terrace is 10-20 m. The gravel consists mainly of quartz, quartzite, and volcanic rock. Most of the gravel is in good condition. During the Early Paleolithic, Liangshan people might have obtained their raw materials on the flood plain next to the Hanshui River. Today, there is still gravel on the river bank, but not much of it is in good condition. I found about 40 workable cobbles, pebbles, and boulders in this gravel. These include quartz, quartzite, and volcanic rock; the average gravel clast weighing 1446 gm. (Fig. II 37). I also selected 10 quartz or granite hammerstones, with an average weight of 800 gm. (Fig. II 37).

Reduction Sequence

All specimens were produced by hard hammer, direct percussion on my upper thigh in the lab (Fig. II 38). It was very difficult to try the technology of block-on-block inside the lab. I tried this technique when I selected raw material in the field and found that it was not very successful. I could take some flakes off that had a breadth greater than the length, but none of them was large enough to be continually retouched into tools. This was not a

question of the quality of the raw material. There were no large gravel specimens, like the large boulders of the Ba River at the Lantian location, that could serve as anvils. The sizes of the individual gravels in this area are fairly even regardless of their source, whether the third terrace or the river bank. This may not have been true at the time of the Middle Pleistocene, but the small gravel size does present a problem now.

Because the raw materials of this area are not difficult to work, the final core tools may be markedly smaller than their primary trimming flakes (Fig. II 39). It is possible to remove some long flakes from one end of the cobble to the other. On some oblong cobbles it is also possible to take off a flake from the corner, and the first primary trimming flake will again be longer than the final tool (Fig. 40). This technique of striking flakes off the end of an oblong cobble, or of producing end-struck long flakes from the cobble, may indicate the means of production for specimens Liangshan 85.19 [F1] and P6277 [F2]. Both of these are made on long, narrow, whole flakes, one was retouched on one lateral edge unifacially, the other was retouched on both lateral edges unifacially.

Because 43 per cent of the flakes in the collection have breadths greater than their lengths, I tried to make some flakes in these shapes by free-hand percussion with hard hammer technique. Such flakes are usually made from

large ovate cobbles, with the flakes being taken off around the edges of the cobble by shallow striking (Fig. II 41). The remaining core would show all bifacial edges [C15], like specimens 85 Liangshan P6289 and 82 Longgangsi P6312 (Fig. II 42). If only one or two flakes were taken off the cobble, the remaining core would have a single unifacial edge [C1]; there were 15 specimens from the collection that were of this type (Fig. II 43). Alternatively, flakes were taken off both faces to form a core with single or double bifacial edges [C9, C10]] (Fig. II 44). There were 11 (12%) specimens that are Core with one bifacial leaf-shaped edge [C13] in the collection. Most of these tools retain cortex on the butt and central part of both surfaces. To make this type of tool one can simply use the same technology as used for types C9 and C10, but leave a point on one end (Fig. II 45). If one trims the tool from one end to the other, extending this action to the entire circumference of the tool will result in a biface (Fig. II 46).

Chapter 4 Shilongtou

In the winter of 1971, workers for an irrigation project next to Daye Lake found some mammalian fossils inside a limestone cave on top of Shilongtou hill of the Zhang Mountains of Hubei province. The archaeologists of the IVPP and the Hubei Provincial Museum excavated this cave in 1971 and 1972. They found more mammalian fossils that resemble what Pei Wenzhong refers to as "typical *Ailuropoda-Stegodon* fauna" or "*Ailuropoda-Stegodon* fauna *sensu stricto*". The geological age of these finds has been determined to be Middle Pleistocene. In the course of the excavation they also found some artifacts *in situ* in a fissure associated with the mammalian fossils. There are no *Homo* remains at this site. Since these two seasons of excavation, no further investigation has been carried out in this area. Shilongtou is the only Early Paleolithic cave site so far known in this area. By the time I visited the site in October 1988, the cave had been destroyed by limestone quarrying, but I collected some mammalian fossils on top of Shilongtou hill. The species of the fossil bones are the same as the ones found inside the cave in 1971-1972 (Fig. III 1).

1. Geological and Archaeological Background

Location

Shilongtou Cave is situated 30 degrees north latitude, 115 degrees east longitude. It is about 100 km southeast of Wuhan city (the capital of Hubei province). Daye county seat is to the west, about 30 km away. The Yangtze River is 4 km northeast of the cave and flows NW-SE in this area. On the southwest side of the Shilongtou Cave is Daye Lake, which is in a basin oriented east-west (Fig. III 2). The area of the lake is 240 square km. There was rice growing in the depression (basin) when I visited the cave. There is a low, narrow ridge running east-west between the Yangtze River and Daye Lake. This ridge is composed of limestone and coal, which were formed in the Late Paleozoic and the Mesozoic. The west section of this ridge is named Huangji, the east section is named Zhang. Shilongtou Cave is on a small spur of the southeast end of the Zhang Mountains. This small spur is 50 m above the surface of Daye Lake.

The cave developed in a thick layer of limestone on the south slope. There were three joints in the layer, and the cave developed along the fracture of the north-south joint (the first joint). The main room of the cave was at the point of intersection of the three joints. The cave had a length of 11 m., and a width of 1 to 4 m. The floor of the cave sloped down to Daye Lake at an angle of 30 degrees. The top of the cave was gone long before the site was

excavated, but the cave mouth may have faced to the south. The lowest level of the cave is about 10 m. above the dry season level of Daye Lake.

Mammalian Fauna

The Shilongtou fossils are quite fragmented, with very few whole specimens. Ten species have been identified: *Hystrix subcristata Swinhoe, Ailuropoda melanoleuca fovealis Matthew et Granger, Hyaena sinensis Zdansky, Felis tigris L. Stegodon orientalis Owen, Rhinoceros sinensis Owen, Sus sp., Pseudaxis sp., Cervus sp.,* and *Bovinae*. Neither Tertiary survivals such as *Machairodus, Chalicotheridae,* and *Mastodon etc.* nor typical forms characteristic in the early Pleistocene such as *Ailuropoda microta, Stegodon preorientalis, and Stegodon zhaotongensis etc.* are present in the assemblages. Thus, the mammalian faunal assemblages of the Shilongtou cave belong to the *Ailuropoda-Stegodon* fauna, which was widespread in south China in the Middle Pleistocene. Compared to the representative fauna of the Middle Pleistocene in south China, such as Yanjinggou, only *Nestoritherium* is absent from the Shilongtou fauna.

Stratigraphy

According to the original excavation report, the deposits of the cave consisted of three layers, from top to bottom (Fig. III 3):

1. Brown reddish clay with stalagmite. Stone artifacts and fossils rare; 0.3-1 m. thick.
2. Yellow and brown sandy clay. Abundant in stone artifacts and fossils; 0.3-1 m. thick.
3. Light brown sandy clay. No artifacts or fossils; 0.5-1.5 m. or more in thickness.

Among the above deposits, the first layer is mainly formed by erosion remains and sediments from the groundwater; the second layer is a cultural layer with sloping remains; and the third layer is also formed by sloping remains. As seen in the longitudinal section, there are very great differences in color between the second and third layers. Several stone specimens were discovered in the top of the second layer that show partially weathered faces. This situation should indicate that these specimens were exposed for a long period before being covered by the next layer. There were some *Hyena* feces in the middle or top of the first layer, suggesting that hyenas used the cave. This was also the case at the Peking Man cave, Location 1, Zhoukoudian.

Around the Shilongtou cave are widely dispersed chains of hills and terraces adjacent to Daye Lake and the Yangtze River. A brown reddish clay covers these geological features in varying thicknesses. This clay is similar to that found in the second layer inside the cave. This brown reddish clay on the terrace should have been formed during

the same geological period as that inside the cave, but to date no cultural remains have been found in the brown reddish clay layer outside the cave.

2. Description and Classification

Previous Work

The excavators of the Shilongtou cave published an excavation report in 1974 (Li, 1974), which is still the best information available. No other systematic studies of this site have been published. There is another cave site, Jiudaohe, in the same geological situation on the other side of the Yangtze River. Li Tianyuan found more mammalian fossils that belong to *Ailuropoda-Stegodon* fauna, and also found 400 artifacts made of quartzite cobbles associated with the mammalian fossils at the cave. A comparative study of this cave and of Shilongtou has been published (Li, 1989).

According to the work at the Zhang Mountains and Huangji Mountains, limestone caves were well developed and widely distributed along various altitudes from the tops of the mountains to the surface of Daye Lake. The highest level is about 100 meters, then 60-80 meters, and 10-40 meters. There is a series of springs next to the lake. Most of the caves are small to medium sized, and contain reddish yellow clay, stalagmites, and limestone deposits as well as some mammalian fossils belonging to the so-called

Ailuropoda-Stegodon fauna of the Middle or Late Pleistocene period. No associated artifacts have been found so far, except in Shilongtou.

Li Tianyuan suggests that the stone artifacts from Shilongtou are made of quartzite, chert, quartz, sandstone, and breccia cobbles. Most of them are fresh and only a few specimens seem to have been polished by wind action. The nuclei and flakes vary in size and shape. The flakes were produced by the direct method with a stone hammer. No preparation of the striking platform can be recognized. There are cores, flakes, chopper-chopping tools, and scrapers. The secondary working is usually irregular and rough. There is not a single piece of a typical bipolar flake or core occurring in Shilongtou.

The most recent published result of the absolute age determination of the Shilongtou cave by uranium series dating of travertines is about 284,000 years (Yuan, 1986). This result supports the view that the age of the Shilongtou fauna belongs to the Middle Pleistocene.

The Collection

There is, as yet, no published total for the specimens discovered in Shilongtou cave. The original excavation report simply states: " [if one] sorts through the stone specimens from the cave site at Shilongtou, removes the broken ones, the debitage, and material that does not show

clear marks of human workmanship, then there are 88 specimens left" (Li, 1974:145). I recorded 24 examples from the collection of the IVPP; these were all I was given permission to study (Table 3). Most of the specimens are in fresh condition. There are no marks or other evidence to suggest the specimens were transported by flowing water.

Core with single unifacial edge [C1] (2 specimens)

Specimen P3822 was made from an oblate quartzite cobble. There are flake scars on one side of the cobble that retain deep negative marks of the bulbs of percussion. The flakes were taken from one direction unifacially, the flake scars are not large, and the edge is not even. The angle of the platform on the core is less than 90 degrees. Eighty per cent of cortex is retained. The length/breadth/thickness measurement is 68x100x54 mm., the weight is 500 gm. (Fig. III 4).

P3842 is made from a flat chert cobble. There were previous working scars on the protruding face and the flat face. The single edge is made from the flat face to the protruding face only. The flake scars on single edge are not even: one of them is large and shallow but most of them are small and short. There are some small retouched flake scars on the sharp edge that are very shallow, and close to 90 degrees. There is edge damage present on the single working edge, and there is cortex on the side opposite this

edge. The length/breadth/thickness measurement is 66x79x24 mm.; the weight is 55 gm. (Fig. III 4).

Core with double unifacial edges [C2] (1 specimen)

P3831 is made on a small, flat, and thick quartzite cobble. These double edges are adjoining; one long edge was flaked unifacially from one direction, the other, short edge was made unifacially from the opposite direction. The angles of these two edges are close to 90 degrees. The flake scars overlop, which strongly suggests that the edge was purposely made steep. There is cortex on only one surface, and there is edge damage present on the double edges. The length/breadth/thickness measurements is 64x64x36 mm, the weight is 80 gm. (Fig. III 4).

Core with unifacial distal end perpendicular to both edges [C3] (1 specimen)

Specimen P3836 is made from a flat breccia cobble. The edges at either side and at the wider butt end are unifacially trimmed and sharp. The butt is thick and rounded and the lateral edges are almost perpendicular towards the cutting edge, which is formed by large shallow scars on both lateral faces and short steep scars on the end. There is cortex on the back face and central section of the other face, and there is edge damage present on the

three edges. The length/breadth/thickness measurement is 113x82x33 mm, the weight is 400 gm (Fig. III 4).

Core with one unifacial leaf-shaped end [C5] (2 specimens)

Specimens P3837 and P3838 are made on quartzite cobbles. P3837 is made on a flat oblong cobble. It is trimmed evenly from the left lateral edge to the tip, but is broken along a fracture line on the right lateral edge. The flake scars on the left lateral edge are steep. The cortex remains on most parts of both surfaces, and there is edge damage present on the double lateral edges and point. The length/breadth/thickness measurement is 127x92x50 mm, the weight is 1,000 gm. (Fig. III 5). P3838 is made on a rough, and subrounded cobble. Both the lateral edges were made unifacially, but in the opposite directions (one lateral edge does have one flake scar on the other face, but the technique is still primarily unifacial). These two opposite directions of triming on the laterals continue to the front edge, which is formed into a bifacially trimmed point. The point of this tool is curved, rather than sharply pointed. The flake scars are of various sizes, and the cutting edges are not even. The butt is thick and rough; there is cortex on both surfaces. This tool shows that unifacial and bifacial techniques can be used alternatively. There is damage present on the double edges and cortex. The

length/breadth/thickness measurement is 105x116x74 mm, the weight is 1,000 gm. (Fig. III 5).

Core with all unifacial edges [C7] (1 specimen)

Specimen P3825 is made on a small irregular quartzite cobble. The profile of the tool is roughly triangular in general form. The edge of the upper face is formed by trimming from the edge to the central flat part around the entire circumference. A small area of flat face remains in the middle. The lower face is trimmed from the edge of the upper face in irregular directions, part of the back is formed by cortex. There is little evidence of edge damage on the edges, and the edges are jagged. The length/breadth/thickness measurement is 57x78x44 mm, the weight is 44 gm. (Fig. III 6).

Core with unifacial edges in other shapes [C8] (2 specimens)

Specimens P3821 and P3823 are made from quartzite cobbles. P3821 is made on a thick, flat, and rounded cobble. The flake scars are present on only one upper face. Flakes have been trimmed from the two adjoining edges of the face, the remaining flake scars overlap in two different directions, and cortex covers the other faces of the cobble. There is pitting and pockmarking on the cortex. The

length/breadth/thickness measurement is 80x78x66 mm, the weight is 800 gm. (Fig. III 5).

P3823 is made on a weathered cobble. The lower face shows single direction flake scars from a straight edge to an curved jagged edge. Both lateral edges and an end edge are steeply trimmed from the lower face to the upper face, and the majority of the upper face is formed by weathered cortex. There is edge damage present on the edges. The length/breadth/thickness measurement is 70x84x73 mm, the weight is 800 gm. (Fig. III 6).

Core with single bifacial edge [C9] (3 specimens)

Specimens P3824, P3841, and P3835 are all made on quartzite cobbles. P3824 is made on a roughly square cobble. Prior to trimming the single bifacial edge, the butt end and one side of the tool were steeply trimmed by flaking from the flat natural surface unifacially. The single edge is jagged and relatively straight; cortex is present on both faces. The edge damage is present on both the working edge and the cortex. The length/breadth/thickness measurement is 100x86x75 mm, the weight is 800 gm. (Fig. III 7).

P3841 is made on a small split cobble. There was a large, flat flake scar on the upper face. The single edge is partially bificially trimmed on both ends to make the edge sharper. The single edge is not even, and exhibits

signs of edge damage. There is cortex on the butt and lower face. The length/breadth/thickness measurement is 74x54x28 mm, the weight is 55 gm. (Fig. III 7).

P3835 is made on a fresh, half cobble. The single edge is relatively even and sharp. There is cortex on the butt and both faces. There is edge damage present on the single edge. The length/breadth/thickness measurement is 66x79x41 mm, the weight is 80 gm. (Fig. III 7).

<u>Flake with single lateral unifacial edge [F1] (4 specimens)</u>

Specimens P3845, P3826, and P3834 are made on thin quartzite flakes, P3830 is made on a thin quartz flake. P3845 is a roughly square flake with a set of perpendicular line ridges on the side of the dorsal face due to the removal of a large flake, which was struck from the back of the proximal end. The single lateral edge was flaked from ventral surface to dorsal. The retouch marks on the single edge are small and even. There is edge damage present on the double lateral edges and distal edge. There is cortex on the platform and back of the distal edge. The length/breadth/thickness measurement is 62x60x18 mm., the thickness/breadth of the platform measurements are 18x38 mm. The angle of the platform is 130 degrees. The weight is 50 gm. (Fig. III 8).

P3830 is made on an oblong flake with one flake scar on the platform. A previous flake was removed from the dorsal

face. One retouch scar is on the thick lateral edge, which is also flaked from ventral surface to dorsal. Another lateral edge is naturally sharp, and shows heavy edge damage. There is cortex on the platform and back of the distal edge, and the distal edge also shows heavy edge damage. The length/breadth/thickness measurement is 79x62x20 mm., the thickness/breadth of the platform is 24x37 mm., the angle of the platform is 120 degrees, the weight is 100 gm. (Fig. III 8).

P3826 is made on a small oval flake. The flake scars are in very fresh condition. The distal end is wider than the platform. Retouch scars are present on one lateral and on the proximal end of the dorsal face. The other natural lateral and the distal edge are jagged. Half the dorsal face is covered by cortex. The length/breadth/thickness measurement is 63x54x16 mm., the thickness/breadth of the platform is 3x34 mm, the angle of the platform is 120 degrees, the weight is 45 gm. (Fig. III 8).

P3834 is made on a rectangular flake. The platform is relatively thick. There are massive flake scars from previous work on the dorsal face. There are two retouch scars on one lateral edge, which were taken from the ventral surface to the dorsal. There is edge damage present. There is cortex on the platform. The length/breadth/thickness measurement is 112x80x30 mm., the thickness/breadth of the

platform is 30x60 mm, the angle of the platform is 130 degrees, and the weight is 380 gm. (Fig. III 8).

Flake with unifacial proximal end [F8] (1 specimen)

Specimen P3833 is made on a thick quartzite flake. The platform of the flake has been removed by trimming on the proximal end and one lateral edge from the ventral to the dorsal face. This edge presents a convex shape. On the end of the same lateral, there is a large flake that was taken off from the dorsal surface to ventral. Although this shows opposite direction trimming, it does not affect the formation of the main working edge. All the edges of the flake exhibit edge damage, especially the lateral with the naturally sharp edge. There is cortex over half the dorsal face. The length/breadth/thickness measurement is 102x72x42 mm, the weight is 400 gm. (Fig. III 10). I do not have measurements of the thickness and breadth of the platform, nor the platform angle because as noted above the platform was removed when the tool was being shaped.

Flake with unifacial distal and proximal ends [F9] (1 specimen)

Specimen P3832 is made on a large thick quartzite flake. The distal edge shows short, wide flake scars that were flaked from the dorsal surface to ventral. There are trimming marks on the proximal end from flakes that were

taken off mainly from the ventral to the dorsal face, but there are also two small flakes that were taken from the dorsal face to the ventral. There is no edge damage on the proximal end of the tool. The retouch of the proximal end seems to have been done in order to provide a hand hold. There is edge damage present on the distal edge. Cortex covers the whole dorsal face. The length/breadth/thickness measurement is 134x136x37 mm, the weight is 1,900 gm. (Fig. III 9). No measurements of the thickness and breadth of the platform, nor of its angle are possible because the platform was removed by the retouching of the proximal end.

Flake with all unifacial edges [F10] (2 specimens)

Specimens P3844 and P3843 are made on quartzite flakes. P3844 has a length greater than its breadth, and P3843 is just the opposite, having a breadth greater than the length of the tool. There are flake scars of various size and depth around the entire circumference of both tools. Retouching of specimen P3844 is from the ventral face to dorsal, there is a central part of the dorsal face that retains cortex. Specimen P3843 is trimmed from the dorsal face to ventral, and the dorsal face is entirely covered by cortex. The angle of the trimming edge of P3844 is greater than that of P3843. The edges of both flake tools are left jagged by damage. The length/breadth/thickness measurements of P3844 are 90x67x28 mm., of P3843 67x87x60 mm. The

thickness/breadth of the platform of P3844 is 22x58 mm., of P3843 10x31 mm. The weight of P3844 is 200 gm., of P3843 100 gm. (Fig. III 10). Because of the removal of the platforms, it is not possible to measure the angles of the platforms on either of these tools.

Flake with unifacial edge in other shapes [F11] (1 specimen)

Specimen P3827 is made on a thin quartzite flake. The tool is roughly square. The platform and one lateral are formed by two vertical fractures with a bulb of percussion at their intersection. Trimming is unifacial and ventral to dorsal along the distal end, the other lateral, and the proximal end. The trimming scars are not even, some are larger than others. The edge is not sharp, and the distal edge shows edge damage. The cortex surface is retained on part of the dorsal face. The length/breadth/thickness measurement is 50x53x23 mm., the thickness/breadth measurement of the platform is 26x38 mm, the angle of the platform is 132 degrees, and the weight is 200 gm. (Fig. III 11).

Unmodified flake [U1] (3 specimen)

Specimen P3829 is a breccia flake, and P3840 and P3828 are quartzite flakes. The lengths of P3829 and P3840 are greater than their breadths, but the length of P3828 is less than its breadth. The bulbs of percussion are very clear on

these three flakes (there are two bulbs on P3828). There is damage on the distal ends of P3829 and P3828. Because the damage on P3829 is more or less straight on the narrow end of the flake, almost anything could have produced such damage; it is not necessarily the result of use during the Lower Paleolithic. But the damage on P3828 is different. There is a shallow notch in the middle of the distal edge that has changed that edge from convex to concave. This is probably use-damaged. There are previous trimming scars on the dorsal faces of these three flakes. On P3840 and P3828, there is still cortex on part of the dorsal face. Cortex remains only on the platform of P3829. There is edge damage present on the double lateral edges of P3829 and P3840. The length/breadth/thickness measurements of P3829 is 56x38x17 mm., P3840 is 64x42x16 mm., and P3828 is 40x74x21mm. The thickness/breadth measurements of the platform of P3829 is 18x33 mm., P3840 is 15x34 mm, and P3828 is 18x42 mm. The angle of the platform of P3829 is 129 degrees, P3840 is 131 degrees, and P3828 is 122 degrees. The weight of P3829 is 35 gm., P3840 is 35 gm., and P3828 is 40 gm. (Fig. III 11).

3. Analysis and Replication

Technology

The raw materials that were selected to make stone tools included quartzite (83%), breccia (8%), chert (4%) and

quartz (4%). Most of the raw materials are gravel cobbles of comparable sizes. The length/breadth/thickness measurements of core tools range from 127x92x50 mm. to 64x64x36 mm., with an average of 82x82x50 mm. These numbers indicate that the raw material cobbles from which the cores were obtained were similar in length and breadth and tended to be somewhat thick. The weights of the specimens range from 1,900 gm. to 35 gm., with an average of 380 gm.

All specimens in this collection retain cortex. The highest percentage is 80 per cent, the lowest one is 10 per cent (cortex present only on the platform), with an average of 40 per cent. The number of flake scars on the core specimens ranges from 10 to 3, with an average of 6. This number suggests that there was a relatively standardized limit to the flakes removed from each core specimen. There are 12 core specimens in the study, 9 were produced unifacially, and 3 are Cores with Single Bifacial Edge. Although the bifacial technique constitutes 25 per cent of the core tools, it is found on the trimming of only one edge.

There are 12 flake specimens. On 2 of them the entire platform has been removed during repair of the proximal end that measurements of the thickness, breadth, and angle of the platform are not possible. Although 2 others retain the thickness and breadth of the platforms, the angles of these are not measureable. Platform thicknesses of the other 8

range from 30 mm. to 3 mm., with an average of 18.4 mm. The platform breadth ranges from 60 mm. to 31 mm., with an average of 40.5 mm. The ratio between the thickness and breadth of the platform is: 1:2.2. There are 5 specimens (40%) that show various flake scars on the platforms, as a result of trimming the proximal edges. Specimen P3840, however, shows two flake scars on top of the platform indicating that it might have been formed before the flake was struck off, or as a result of the blow that detached the flake. There are 4 specimens (33%) that retain cortex on the platform. Platform angles range from 132 to 120 degrees, with an average of 127 degrees, which is quite high. The bulbs of percussion are well marked. All the flake specimens are made unifacially. Seven of them (78%) are flaked from the ventral face to dorsal; one (P3843) of them is flaked from dorsal face to ventral. Another (P3832) is flaked from opposite directions between the proximal edge and the distal edge. The weights of the flake specimens range from 1,900 gm. to 35 gm., with an average of 290 gm.

Making a tool by trimming the different edges from opposite directions seems to be distinctive to the industry of this cave site. Specimens P3831 [C2] and P3838 [C5] are made by this technique, which is used on the two lateral edges. On P3838, there is overlap of these two directions on the end, making this area bifacial. Using this tool as an example, we should note that, in practice, the unifacial

and bifacial techniques are by no means mutually exclusive. I classified this tool under the unifacial technique because 60 per cent of the edge is formed unifacially, yet 40 per cent of the edge was flaked bifacially.

The flake specimens are usually rather small. The length/breadth/thickness measurements range from 134x136x37 mm. to 50x53x23 mm., with an average of 77x69x27 mm. There are 8 (67%) in which breadth is greater than length (I count only the ones for which length and breadth are clearly different). It is difficult to say whether any technique other than free-hand hard hammer percussion was used. Each specimen of Shilongtou has its own style, and it is very difficult to classify them into types. I have, therefore, described the specimens one by one. This situation may indicate that the Shilongtou stone tool industry was not very well defined; or it may mean simply that the shapes of the raw materials were not very regular, hence production on the basis of these raw materials had to be opportunistic.

Selection of Raw Lithic Material

As noted earlier, there is rice growing in the Daye Lake basin today. Even if there were a source of gravel cobbles on the bank of the Daye Lake in the Middle Pleistocene, they are not present now. Such gravel cobbles were probably covered by lacustrine deposits long ago. I also investigated the area from the cave to the Yangtze

River, and along the south bank of the Yangtze. The river dikes are very high, there is no floor plain for any kind of gravel, whether large or small. About 15-20 km northeast of the cave, the Yangtze River branches and flows around several towns. The water in these branches is shallow, and here are large cobbles on the river bed, covered by river mud. The average weight of these cobbles is about 1,000-1,500 gm. The enclosures and roads of each family around these branches are all made from these kind of cobbles. I measured 55 cobbles. The sizes are regular, the length/breadth/thickness measurement ranging from 178x126x80 mm. to 96x82x50 mm., with an average of 135x104x65 mm. The weights range from 500-1,200 gm., with an average of 595 gm. These numbers are similar to the measurements of specimens from the Shilongtou Cave. The shapes of the stone cobbles vary, however (Fig. III 12), and they include quartzite, quartz, and sandstone (Appendix A). These materials are quite hard to work. It is especially difficult to produce a perfect long flake, and it is also hard to find a good hammerstone because the sizes, weights, and or the shapes of most of the cobbles make them unsuitable for such use.

The chert nodules that were used in Shilongtou Cave by hominids came from the nearby limestone, which was formed in the Permian period. Chert nodules presently available here are much weathered and easy to break up, so chert was not the best choice of raw material for making stone tools.

That is probably why there is only one specimen made of chert in the collection (I was unable to find any chert nodules near the site at the time of my visit).

Reduction Sequence

All specimens were produced with hard hammer direct percussion, using my left thigh to support the stone. I used only one hammerstone for the replication (dimansions were 159x105x56 mm., weight 1,100 gm.). This was an ovate sandstone cobble with calcium cementing material on part of the surface. The hammerstone was strong, but by the end of the work there were chipping marks around 75 per cent of the edges (Fig. III 13). Some of the chipping marks resemble trimming flake scars. As a result, I am not sure how many people would classify this hammerstone correctly if it were found in an archaeological excavation.

Most of the core tools in the collection were made on comparatively flat cobbles, such as specimens P3822, P3842, P3831, P3836, P3837, P3823, P3821, and P3824. When most of the cobbles are flat, I found it was easy to take the flakes off at angles of 90 degrees or a little less, for the purpose of producing flakes (see specimen P3823) (Fig. III 13). But I produced only a few large flakes during the replication work. I also noted that bifacial trimming of a working edge does not always make the edge sharper than

unifacial trimming when the raw material is a flat cobble (Fig. III 14).

There are few sharp points on any of the specimens. Even on the tip edge of specimen P3838, there is still a certain curved rather than pointed shape. This does not mean that small points could not be made bifacially, however (Fig. III 15). The shapes of the flakes vary according to the shapes of the cobbles (Fig. III 16). If you unifacially trim a single edge steeply, then the flake shapes are usually wider than they are long (Fig. III 18). But there was no great difference between the quantities of wide flakes vs. long flakes in the collection (Fig. III 19). Therefore, the technique of percussion in the Shilongtou industry was accommodated to the condition of the local raw material (Fig. III 17).

I found one large flake (length/breadth/thickness measurement 196x340x72 mm., weight 1,100 gm., and platform angle 127 degrees) near an enclosure when I collected the raw material. Nobody remembered how or who broke this flake, or where it came from. This flake was found when they built the enclosure. There are two bulbs of percussion on the platform. These two bulbs are not on a flat line and there is a big crack between them; hence the flakes might have been formed by repeated blows. We do not know how old this flake is, but it demonstrates that the local raw material can be made to produce large flakes (Fig. III 20).

From my experience with replicative work at Shilongtou, I belive that to produce such a large flake requires a very big boulder as the initial lithic material, and then either a great amount of strength or an iron hammer as would be used today.

Chapter 5 Guanyindong

In 1950, local farmers of the Shajing commune in Qianxi county, Guizhou province, opened a cave that had long been sealed (Fig. IV 1). In the winter a crevice at the mouth of the cave had been giving off vapor. Local people called it Guanyindong (Guanyin means Avalokitesvara Bodhisattva, Dong means cave). The thickness of the deposits differs significantly from the mouth to the back of the cave: grain sizes run from large to small, and the strata vary from thick to thin (from 4.8 down to 2 meters) (Figures IV 2 and IV 3). The upper levels of the deposit derived mainly from outside the cave. There are various thicknesses of stalagmitic crust covering most of the deposits, but not those in the north branch cave. Local people disturbed the north branch of the cave, so archaeologists noted the first stone specimens from this area even before they started to survey. At the end of the other branch of the cave, local people had dug several holes in the stalagmitic crust in search of "dragon bone." These excavations revealed the first group of mammalian fossils found during the survey.

This survey took place in the winter of 1964 when Pei Wenzhong led a field team organized by the Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, and the Provincial Museum of Guizhou to the cave. Excavations were conducted in 1965, 1972, and 1973. A large quantity (23 families and 13 species, about 300 specimens

total) of fossil remains was found in association with stone tools. No one has as yet looked for cut marks on the bones or studied the patterns of bone breakage. Yet, Luchterhand (1984) contends that there is no known link between these fauna and Pleistocene hominids. He is correct in that no hominid remains have been found in association with the animal fauna, but stone tools most definitely are in association with the fauna. Fossil remains and stone tools were not evenly distributed in all locations, but this is because the bones and tools differ in relative quantities, and not, as Luchterhand suggests, because there is no association between bones and tools. The fossil mammals belong to the *Ailuropoda-Stegodon* fauna complex of the Middle Pleistocene. There are over 2,323 recorded stone tools, Pei Wenzhong suggests that since these stone specimens and the mammalian fossils are both found in deposits covered by a thick layer of stalagmitic crust, the Paleolithic age of the collected chert implements can be confidently assumed (Pei, 1965).

1. Geological and Archaeological Background

Location

Guanyindong is situated at Jingshan village, Shajing commune, Qianxi county, about 152 km. northwest of Guiyang city (the provincial capital). It lies at 27 degrees north latitude, 106 degrees east longitude (Fig. IV 1).

Geomorphologically, Qianxi county belongs to the Qianzhong mountainous region of China, and is about 1,250-1,500 meters above sea level. Near Guanyingdong, Permian-Triassic limestone and shale are present and the karst landscape is well developed. There are many mountains and hills in the area, but only two kinds of general surface configurations. From Guanyindong north 8.5 km. the surface is characterized by stalagmitic and corrosion gullies. The limestone is exposed. There are sinkholes, vertical shafts, trough valleys, and low-lying lands between the ridges and peaks. The second kind of landscape is the Permian-Triassic shale, which forms rolling hills. Soils are well developed and covered by dense forest, thus forming a sharp contrast with the bare mountains. Ten kilometers south of the cave is the Liuchun branch of the Wu river. The river bed is 200-400 m. lower than its terraces. There is a series of trough valleys and depressions from the cave to the river, much like a flight of stairs, and there are few surface streams.

Guanyindong is located on the central line of the anticline. There is an east-west strike joint here, and a south-north strike joint crosses it. The cave developed from a fracture of the east-west strike joint. There are two branches: the south one is about 15x1 m. length by width; the north one is 30x1-2 m. with a small opening. The main cave has a length of 90 m., a width of 2-4 m., and a

height (from the surface of the deposit to the roof) of 2-8 m. (Figure 2a). The main entrance is at the west end of the main cave, and lies on the edge of a closed depression (south-north 700 m. by east-west 500 m.), planted with rice. The cave mouth is 15 meters above the ricefields. This depression was developed within a thick layer of Triassic limestone. On the northwest side of the depression are coal dating from the Permian Period. There is a spring here, and the water from the Permian layer runs through the depression toward Guanyindong, where it becomes an underground stream. So Guanyindong probably formed as a thoroughfare for phreatic water in the late Tertiary or the early Quaternary Period.

Stratigraphy

The representative section of cave deposit is at the west entrance (Fig. IV 4). The deposits here are more than 8 meters thick, and are divided into 9 layers (Li, 1986).

1. Black sandy clay, 15-70 cm thick.
2. Red clay with much rock debris. The upper portion is darker than the lower one. Stone specimens and mammalian remains were found in this layer, which is 40 to 240 cm. thick.

Denudation surface

3. Brown yellow, or gray yellow loose sandy clay with limestone blocks and pebbles. A few stone specimens

and mammalian remains were encountered in this 30 to 160 cm. thick layer.

4. Brown yellow, or red yellow sandy clay with limestone blocks and pebbles, covered by a layer of hard stalagmitic crust. There were stone specimens and mammalian remains here, and the layer is 90-150 cm. thick.
5. Gray sandy clay with limestone pebbles. Many stone specimens and mammalian remains were found in this 10-15 cm. thick stratum.
6. Brownish yellow or reddish yellow sandy clay containing stone specimens and mammalian remains. This bed is 20-60 cm. thick.
7. Gray or yellow, variegated sandy clay with limestone pebbles. Stone specimens and mammalian remains were found in a 15-70 cm. thick layer.
8. Yellow, variegated rough sand with limestone pebbles and blocks. A few stone tools and mammalian remains were found in a stratum 15-50 cm. thick.
9. Archaeologically and paleontologically sterile layer of intermixed rough sand, pebbles, and clay, 450 cm-? thick.

The excavators have divided these deposits into three groups: Group A (Layer 2), red clay; Group B (Layers 3-8), yellow deposits; and Group C (Layer 9). The stone specimens and mammalian remains were found only in Group A and Group

B. There is a Denudation Surface layer of unspecified thickness between the Group A and Group B. This surface indicates that there was a relatively long period when no cultural deposits accumulated.

The section just described is similar to other sections at other locations (Figure 2b), but most other sections show only Group B, and some of them run deeply into Group C. It is likely that there was no red clay (Group A) deposit inside the cave. This red clay deposit is not only later than the yellow deposit, but also it is present only at the mouth of the west entrance.

Mammalian Fauna

Mammalian fauna from Group B deposits includes 23 families and 13 species: *Eulota (Cathaica) sp., Testudinidae indet., Macaca sp., Hystrix cf. subcristata Swinhoe, Rhizomys cf. sinensis Gray, Vulpes cf. vulgaris L., Ursus thibetanus kokeni M. et G., Ailuropoda melanoleuca fovealis M. et G., Mustelidae indet., Crocuta ultima Matsumoto, Panthera cf. tigris L., Gomphotheriidae indet., Stegodon cf. orientalis Owen, Stegodon guizhouensis Li et Wen sp. nov., Equus sp., Megatapirus augustus M. et G., Rhinoceros sinensis Owen, Sus cf. scrofa L., Muntiacus sp., Cervus (cf. Pseudaxis) sp., Rusa sp., Bovinae,* and *Capricornis sumatraensis Bechstein.* These include *Gastropoda (1), Chelonia (1), Primates (1), Rodentia (2),*

Carnivora (6), *Proboscidea* (3), *Perissodactyla* (3), and *Artiodactyla* (6).

According to the original excavation report (Li, 1986), the mammalian fauna of Group A contains 4 species: *Hystrix* sp., *Stegodon* sp., *Rhinoceros sinensis Owen*, and *Bovinae*. Group B fauna may be characterized as follows: first, by the presence of *Ursus thibetanus kokeni M.* et *G.*, *Ailuropoda melanoleuca fovealis M. et G.*, *Crocuta ultima Matsumoto*, *Stegodon guizhouensis Li et Wen sp. nov*, *Stegodon cf. orientalis Owen*, *Megatapirus augustus M.* et *G.*, *Rhinoceros sinensis Owen*, and *Gomphotheriidae indet*. Eight species are extinct forms (57.14 %), among them *Ursus thibetanus kokeni M.* et *G.*, and *Ailuropoda melanoleuca fovealis M.* et *G.* which differ only in size, both being larger than the modern species.

Second, by the presence of *Gomphotheriidae indet.*, represented by one right upper M1 or DM4 with three bunodont lophs and one isolated bunodont cusp. The pattern of the upper tooth recalls that of *Anancus* or *Pantalophodon*, while the configuration of the lophs is identical to that of intermediate cheek teeth in *Gomphotherium*. The structure of the third loph is also the same as in *Gomphotherium*. *Gomphotherium*, which is usually found in the Lower Pleistocene period or the Tertiary period, is a survivor from those earlier eras. *Hystrix cf. subcristata Swinhoe* is also present from the Lower Pleistocene.

The third characteristic species is *Stegodon cf. orientalis* Owen, which presents some elements or primitive characters of *Stegodon preorientalis Young* from Babu, Guangxi province, and also resembles *Stegodon orientalis* Owen from Yanjinggou, Sichuan Province (Middle Pleistocene). *Stegodon guizhouensis sp. nov.* is a new species in China. It is represented by one right lower M3, which is smaller than the one in *Stegodon orientalis* Owen. In general, this species is similar to *Stegodon hypsilophus Hooijer* from the Djetis fauna of Java (early Middle Pleistocene period).

Fourth, 73 percent of the species belong to the *Ailuropoda-Stegodon* fauna of the Middle Pleistocene period, commonly found at cave sites in south China. Therefore, the Group B fauna is associated with the Middle Pleistocene period.

Group A species also belong to the common *Ailuropoda-Stegodon* fauna. Because there were only a few fossil remains, it is difficult to subdivide them. In fact most of these species could go on to the Upper Pleistocene or even the Holocene.

Dating

Absolute age determinations for Guanyingdong by uranium series dating have been published several times: the first estimate was 115,000 +/- 7,000 y BP for the lowest layer of the deposit with stone specimens and mammalian fossils; this

date is representative only of Group B (Yuan, 1986). The second estimate was 40,000 y Bp for Group A, and 230,000 y BP for Group B (Shen, 1990). These figures were arrived at by dating the stalagmite canopy on the cave wall and the layer of stalagmitic crust. According to the author of the more recent report (1990), cultural remains might not be continuous between the deposits in different locations of the cave. This suggestion not only contradicts the original interpretation of both Group A and Group B belonging to the Middle Pleistocene period, but also pushes the date of Group A beyond the range of the present study. The question is whether there is a cultural difference between these two groups.

Li Yanxian (the author of the excavation report) has published a comparative study of the stone tool technology for both groups (Li, 1983). He comes to seven conclusions: 1) there was less chert and more fine sandstone used as raw material in Group A; 2) there were more flakes in Group A than in Group B, but there were fewer tools in Group B; 3) there are fewer broken pieces of cores in Group A than in Group B (from 44% to 28%); 4) there is an increase from Group A to Group B in the number of flakes with lengths greater than 7 cm. (from 10% to 20%), as well as an increase in the number of regular flakes (from 12% to 20%); 5) in Group A most retouch angles on edges decreased (less than 75 degrees), the edges became relatively even, and tools are

more regular in shape; 6) in Group A the tools are much smaller (from 2.3% to 0.7% for tools with lengths greater than 10 cm, an increase of 14% to 18% for tools with lengths less than 3 cm.); and 7) there is a decrease from Group B to Group A of chopper-chopping tools from 6% to 3.9%, and an increase in points from 3.9% to 4.4%. Li points out that, although there were two culture stages in Guanyindong, because the stone specimens in both groups are associated with the *Ailuropoda-Stegodon* fauna complex, Group A is probably within the Middle Pleistocene period as is Group B. Nevertheless, I include only Group B in this study, because only the material from those levels can be said with certainty to be Lower Paleolithic.

2. Description and Classification

Previous work

In the 1964 test excavation at Guanyindong, five locations were sampled (Pei, 1965). These five locations covered most of the area within the cave (Fig. IV 2): (1) west mouth; (2) 16 meters from the west mouth at the main entrance; (3) the intersection of main entrance and south branch; (4) the intersection of main entrance and north branch; and, (5) the end of the south branch. All locations were dug 2-4 meters deep. From the 5 excavation sections we can see that stone tools and mammalian fossils are found in association in every location (Fig. IV 3). The results of

the excavations in 1972 and 1973 at the west entrance tallies with these 5 sections of test excavation.

After the first excavation in 1964, Pei Wenzhong said: "we now face a new task in Paleolithic archaeology. It is possible that Guanyindong is an example of a new cultural system of Paleolithic caves in southern China, which is somewhat similar to Paleolithic culture in northern China but different from those found in Europe" (Pei, 1985:279). In 1978, Jia Lanpo noted that the site of Guanyindong is known as the richest source of paleololithic stone tool assemblages south of the Yangtze River, that the characteristics of these stone tools are different from those of northern China, and that future discoveries may demonstrate a major cultural tradition here (Jia, 1978). Zhang Senshui and Cao Zetian think that the Guanyindong culture is easily distinguishable from those of the same period in northern China (Zhang, 1980). Although there are some differences of emphasis, all agree that the Guanyindong site represents a new challenge to the old way of thinking about Paleolithic cultures of southern China.

The total number of stone specimens studied was 2,323. Li Yanxian thinks that most of these specimens are made of siliceous limestone, but there are specimens of other material: chert, chalcedony, sandstone, and mudstone. Group B yields 1,444 specimens, including 1,018 (70.49%) tools. There are almost no pure flakes without use or retouch.

Most tools are made on flakes, most of which are 3-5 cm in length. There is no systematic preparation of cores or platforms. The edge angles are usually around 90 degrees. The retouching scars are steep, and the edges are often thick and blunt. There are more complex implements made by different directional retouch on different edges. Types described include cores, flakes, scrapers (end scrapers and concave scrapers), chopper-chopping tools, points, and burins. Most flakes were produced by the direct, free hand, percussion method with a stone hammer. There are also some flakes made by block-on-block technique.

There were abundant stone specimens from the area around the west mouth of the cave, and some of the flakes and cores could be refitted (put back together), so this locale may have been a knapping site. There were fewer mammalian fossils here at the west mouth than inside the cave. These facts, together with the unevenness of deposits inside the cave suggests to the excavators that stone specimens and mammalian fossils were probably carried there by flowing water (Li, 1986).

The Collection

I recorded 37 examples of Group B stone tools from the collection of Li Yanxian (he chose a total of 59 specimens for my study, but 22 of them belong to Group A). These 37 specimens represent each type included in the original study

(Table 4). Some of them were partially covered with calcium cemented material and iron oxides, but they are basically in fresh condition.

Core with unifacial edges in other shapes [C8] (6 specimens)

Specimens P4119 and P4114 are made from large volcanic nodules, and specimens P4116, P4117, P5255, and P4118 are made from smaller chert nodules. All the specimens exhibit areas of smooth cortex surface, indicating that they were made from nodules. Some retain more cortex than others. For example, P4119 and P4114 retain 33 to 50 percent of cortex, P4117, P5255, and P4118 retain only 8-10 percent cortex.

Most cores were flaked from one platform to the opposite end (see P4119, P4114, P4116, P4117, and P5255), but P4118 was flaked from two platforms. P4118 is roughly a parallelopiped with two large flat surfaces, and four smaller side faces. There were flakes taken off from a long side and joined short side of the upper surface. Flakes were also taken off from a short side of the lower surface (Fig. IV 5).

The platforms of specimens P4119 and P4117 are formed by natural flat faces on the nodules (Figures IV 5 and IV 6). The surfaces of the platform are roughly square or pentagonal, flakes were taken from three or all the sides of the cores. The shapes of the flakes are irregular, but the

flakes of P4119 are larger and more uneven than those of P4117. This may be related to the sizes of the original cores and the quality of the raw materials. The profiles of these cores are roughly cone shaped.

The platforms of P4116, P4114, and P5255 are flat surfaces with negative flake scars. On P4114, the flakes were probably taken off the two sides of the platform without any prior preparation (Fig. IV 6). There are small trimming scars like scales on the edges of the platforms of P4116 and P5255. These small scars are related to larger flake scars, indicating a stage of preparation before the large flakes were taken off (Fig. IV 6). The flakes were removed from three sides of the core on both specimens.

There is light edge damage present on specimen P4114, but there is more obvious edge damage present on the rest of the specimens. The locations of this edge damage differ from specimen to specimen: there is damage on all the edges of P4118; on the proximal surfaces of P4119, P4116, and P4117; and on one edge of P5255. The length/breadth/thickness measurements range from 107x81x100 mm. to 32x20x51 mm., with an average of 79x54x60 mm. The weights range from 1,500 to 45 gm., with an average of 469 gm.

Core with one bifacial end perpendicular to both edges [C11] (1 specimen)

Specimen P5292 is made on a small chunk of chert. The shape of the tool is roughly a square, the distal end being perpendicular to both edges with a thick, convex, proximal end. The proximal end is made unifacially, the rest of the edges are made bifacially. The trimming scars are not of the same size, some being larger than others, but the edges are still even. There is cortex on the central part of the upper face, and the lower face is entirely covered by flake scars. From a cross-sectional view, the upper face is more convex than the lower face. The angles of the edges are between 75-85 degrees, and damage is present on all three edges. The length/breadth/thickness measurements are 36x40x24 mm., the weight is 39 gm. (Fig. IV 7).

Core with one bifacial leaf-shaped end [C13] (1 specimen)

Specimen P4266 is made on a chert nodule, and is almond-shaped. Seventy-five per cent of the circumference of the tool is carefully bifacially retouched, only a small part of the cortex retains on one lateral edge. The surface of the cortex is not flat, but is covered by a thick crust. If the flintknapper wanted to remove this cortex in order to trim this edge bifacially, it is very possible that she or he could strike off the entire piece of edge with cortex, leaving a straight lateral edge. But the shape of the tool

would not be uniform as it is at present. Because 25 per cent of the circumference and lateral edge retain cortex, the original report called this tool a semi-handaxe. The point of this tool is slightly damaged, and there is also pitting on the butt (proximal end). Although the butt is trimmed bifacially, it is thicker than the point. The length/breadth/thickness measurements are 80x60x30 mm., the weight is 164 gm. (Fig. IV 7).

Core with all bifacial edges [C15] (1 specimen)

Specimen P5266 is made on a roughly triangular slab of chert. There is a large section of cortex on the upper face, and the lower face is covered by flake scars struck from different directions. There are retouch scars on all the edges, but some of them are large deep scars while others are very slight. The angles of the edges are between 65 and 90 degrees. The long edge is jagged, and two short edges exhibit edge damage. The length/breadth/thickness measurements are 101x102x34 mm., the weight is 500 gm. (Fig. IV 7).

Core tools in other shapes [C17] (1 specimen)

Specimen P4115 is made on a small chert nodule, and is roughly ellipsoid in shape. There are two long end flake scars that were struck off from the opposite ends of one face of the core. There are two other short flakes that

were taken off in different directions from the other face of the core. Fifty per cent of the surface retains cortex, and there is pitting on the cortex surface. The length/breadth/thickness measurements are 48x43x38 mm., weight is 100 gm. (Fig. IV 7).

Flake with double lateral unifacial edges [F2] (2 specimens)

Specimen P5271 is made on a long volcanic flake, and P3957 is made on an almond shaped, thick chert flake. P5271 is a very irregular triangular form. One lateral has a flange angle (120 degrees), which stands out one-third of the way to the proximal end and retains cortex, which may indicate that this flake was taken off a corner of the original block. The other lateral is concave with a rough uneven edge. There are retouch marks on both lateral edges but they are from opposite directions: the retouch on the convex lateral is from ventral face to dorsal, on the concave lateral it is just the opposite. In comparison, the trimming scars on the convex lateral are done more finely, with more detail than the ones on the concave lateral. The angle of the retouch is large on both laterals, around 85 degrees, so the edges are quite steep. There are three flake scars on the platform, which were formed before the flake was taken off. The bulb of percussion is clear. The point of the flake is not very sharp. The main edge damage is present on the concave lateral. The

length/breadth/thickness measurements are 96x50x28mm., the thickness and breadth of the platform are 24x30 mm., the angle of the platform is 100 degrees, the weight is 120 gm (Fig. IV 8).

The platform of P3957 is a flat surface without any cortex. This indicates that a flake was taken off to prepare this platform. One of the laterals still retains cortex on the dorsal face with trimming scars from dorsal face to ventral. Another lateral edge is trimmed from ventral face to dorsal with only a little cortex on the edge; in fact, the tip edge is formed bifacially. The shape of the flake basically follows the original shape of the nodule. The bulb of percussion has cracked off, and edge damage is present on the double lateral edges. The length/breadth/thickness measurements are 82x68x50 mm., the thickness and breadth of the platform are 18.5x46 mm., the angle of the platform is 127 degrees, the weight is 188 gm. (Fig. IV 8).

<u>Flake with unifacial distal end perpendicular to double lateral edges [F3] (7 specimens)</u>

Other than P4261, which is made on a large volcanic flake, the rest of the specimens are made on chert flakes. The shapes vary from rectangular to roughly triangular, but the distal ends are all made unifacially. There is edge damage present on all the distal edges. At the same time,

there are also trimming scars on the double laterals of most specimens. P4261, P5289, and P5354 also show retouch scars on the platform, perhaps to prepare one more edge for use (see P5289). Only specimen P5366 has the distal edges made from dorsal face to ventral, the distal edges of the other specimens are all made from ventral face to dorsal. The retouch scars on the edges of the chert flakes are usually even and small, but on the edge of the volcanic flake they are large (see P4261). There is no cortex on P5289, but there is on all the other specimens. The location of the cortex is different for each tool, however: cortex is retained on part of the dorsal faces of P4261 (1/10) and P4274 (1/6); on the platforms of P5303 (1/16) and P5366 (1/14); and on part of the dorsal faces and platforms of P4276 (1/2) and P5354 (1/4).

On specimens P4261, P5289, P5303, and P4276, breadth is greater than length, so there is a longer distal edge. The length/breadth/thickness measurements range from 108x164x44 mm. to 36x57x10 mm., with an average of 65x96x26 mm. (Figures IV 8, IV 9 and IV 10). On P4274, P5366, and P5354, the breadth is smaller than the length. The length/breadth/thickness measurements range from 115x94x45 mm. to 45x30x20 mm., with an average of 71x56x25 mm. (Fig. IV 10). Although there is quite a difference between the lengths of the distal edges (ratio is 1.7:1), there is no particular selection of retouch location for either shape.

The thickness/breadth measurement of the platform ranges from 32x158 mm. to 0.9x14 mm., with an average of 21x53 mm., the weight ranges from 1,000 gm. to 18 gm., with an average of 278 gm. The angle of the platform ranges from 133 to 118 degrees, with an average of 125 degrees.

Flake with unifacial distal point [F4] (1 specimen)

Specimen P5299 is made on a small triangular chert flake. There is a ridge on the front section of the dorsal face, so the cross-section of the point is also triangular. The cross-section of the proximal end is roughly trapezoid shaped. There are retouch scars on the proximal end, both laterals, and the back ridge of the point All the scars were trimmed from ventral face to dorsal. The platform has been taken off by trimming on the proximal end, so there is no available measurement for the angle of the platform. There is also no cortex. The angles of both lateral edges are about 75 degrees, and there is edge damage present on them. There is also edge damage on the point of the tool. The length/breadth/thickness measurements are 40x30x13 mm., the thickness and breadth of the platform are 0.8x30 mm., the weight is 12 gm. (Fig. IV 10).

Flake with unifacial distal [F7] (1 specimen)

Specimen P5277 is made on an irregularly shaped chert flake. The platform is not flat, but is cracked into two

percussion bulbs. There are small trimming scars on the convex distal end, which were formed from ventral face to dorsal. There is a small section of cortex on the distal end of the dorsal face. One of the laterals has been made quite concave on the middle section by three large retouch scars that were made from dorsal face to ventral. This lateral edge is left jagged. Another lateral is convex in form shows some light damage. The length/breadth/thickness measurements are 48x30x21 mm, the thickness/breadth of the platform is 1x20 mm., the angle of the platform is 90 degrees, and the weight is 27 gm. (Fig. IV 11).

Flake with unifacial proximal end [F8] (1 specimen)

Specimen P5258 is made on a small triangular chert flake. The platform is thick, with retouch scars that were flaked from ventral to dorsal face in order to sharpen the edge of the platform. The natural edges of the flake are sharp, with edge damage all around. There is no cortex. The length/breadth/thickness measurements are 38x60x22 mm., the thickness/breadth is 22x46 mm., the angle of the platform is 105 degrees, and the weight is 21 gm (Fig. IV 11).

Flake with all unifacial edges [F10] (4 specimens)

All four specimens are made on chert flakes. Almost one-hundred per cent of the circumference is retouched on

each tool, but from different directions, and there is edge damage present on all the edges. P5276 is made on a thick flake. It is roughly rectangular in shape, but there are projecting lips on the middle of the one lateral. There is a small section of cortex on the platform (1/16). Retouch was from ventral face to dorsal (Fig. IV 11). P5312 is round in form. Retouch scars are evenly spread around the ventral face. There is a small section of cortex on the edge of the dorsal face (Fig. IV 11). P5311 is a small ellipsoid tool. Two lateral edges are quite straight, but the distal and proximal edges are convex. The retouch scars are concentrated on the dorsal face, and there are three shallow scars on the ventral face. This specimen does not retain any cortex (Fig. IV 11). P3890 is a comparatively larger tool. The distal edge is longer than the proximal edge, with protuberances at the corners of both the lateral and distal edges. The retouch scars are basically on the dorsal face, but several of them are also on the proximal end of the ventral face. The bifacial trimming on the proximal end reduced the thickness of the edge, and the angle of the platform has been removed. There is no cortex on this specimen (Fig. IV 11). The length/breadth/thickness measurements of P5276 are 56x50x32 mm., of P5312 are 50x56x17 mm., of P5311 are 26x16x10 mm., and P3890 are 80x113x22 mm. The thickness/breadth measurement of P5276 is 30x50 mm., of P5312 is 16x45 mm., P5311 is 1.5x2 mm., and

P3890 is 23x79 mm. The angles of the platforms on P5276, P5312, and P5311 are all 125 degrees. The weight of P5276 is 65 gm., of P5312 is 62 gm., of P5311 is 4 gm., and of P3890 is 300 gm.

<u>Flake with bifacial distal end perpendicular to double lateral edges [F14] (2 specimens)</u>

Specimens P3951 and P5367 are made on roughly square chert flakes with rather thick platforms. On P3951, half of the platform retains cortex, the other half of the platform is a flake scar that was the preparation for the flake. The bulb of percussion is at the junction of these two halves. The platform of P5367 was formed in the same way as that of P3951, but most of the cortex on the platform has been removed. The bulb of percussion is also at the junction of the flaking scar of the platform. There are several retouch scars on the back edge of the platform of P3951. The bifacial retouch scars are on the distal and both lateral edges of both specimens, but some places show fewer retouch scars than do others. There are natural surfaces on both dorsal faces. Edge damage is present on the distal edge of P3951, and on all the edges of P5367. The edges of P3951 are more even than the edges of P5367. The edges of P5367 are jagged, and there is a clear breach on one lateral edge. The length/breadth/thickness measurements of P3951 are 64x74x24 mm., of P5367 are 57x52x16 mm.; the

thickness/breadth of P3951 is 24x42 mm., of P5367 is 16x38 mm.; the angle of the platform of P3951 is 130 degrees, of 5367 is 115 degrees; and the weight of P3951 is 112 gm., of P5367 is 40 gm. (Fig. IV 12).

<u>Flake with bifacial distal point [F15] (1 specimen)</u>

Specimen P3907 is made on a long triangular chert flake. The platform retains cortex and is much thicker than the distal part. There is a ridge from the proximal end through to the distal end of the dorsal face. There is disconnected bifacial trimming on both lateral edges which forms a point on the distal end. The edge angle at the point is about 87 degrees, but the lateral edges are around 75 degrees. The edges are not even, but are jagged on both laterals. Length/breadth/thickness measurements are 80x48x23 mm., the thickness and breadth are 23x43 mm., the angle of the platform is 115 degrees, and the weight is 71 gm (Fig. IV 12).

<u>Flake with bifacial distal and proximal ends [F20] (1 specimen)</u>

Specimen P5297 is made on a chert flake. The proximal and distal ends are convex, and both the lateral edges are concave. Although there are some retouch scars from opposite directions on both lateral edges, bifacial retouch scars are most abundunt on the proximal and distal edges.

There is no edge damage present on the proximal end, but there is on the distal edge and one lateral edge. There is no cortex on the tool. The length/breadth/thickness measurement is 41x44x13 mm., the thickness/breadth is 10x22 mm., the angle of the platform is 120 degrees, and the weight is 25 gm. (Fig. IV 12).

<u>Unmodified flakes [U1] (7 specimens)</u>

Specimen P3953 is made on a volcanic flake, the rest of the specimens are made on chert flakes. There are flake scars on most of the platforms, but these are made from different directions. In most cases, small flake scars on the platform were formed before the flake was taken off the core, as preparation for the angle of platform (see P5260, P3959, P5257, and P3946). This is especially clear on the platform of P3959 (Fig. IV 13). The platform of P3941 is formed by two large flake scars, the bulb of percussion being under the ridge of these two scars (Fig. IV 13). The proximal end is thinner than the distal end, and there is a large area of cortex remaining on one lateral and the distal end of the dorsal face. There is cortex on the platforms of specimens P5256 and P3953, but the platform of P5256 is small and thinner than the middle cross-section of the flake, the platform of P3953, which is the thickest part of the cross-section of the flake (Fig. IV 13). The length is greater than the breadth in all specimens. There are long

ridges from the proximal ends to the distal ends of the dorsal faces of P3946 and P5257, the two laterals are roughly parallel, and the lengths of the flakes are more than 2 times their breadth. The shapes of these two regular flakes are close to the shape of a common pressure blade. P5260 is the smallest flake. The flake scars are very even on its platform. There is edge damage present on all the specimens, but these are at different locations for each flake. The edge damage is present on the single lateral of P3946, P5257, and P3941; on the double laterals of P5256; on the single lateral and distal edges of P3959; and on the double lateral and distal edges of P3953. The length/breadth/thickness measurements range from 74x42x38 mm. to 26x18x8 mm., with an average of 54x34x16 mm. The thickness/breadth of the platform measurements range from 33x34 mm. to 1.5x17 mm., with an average of 12x28 mm. The angles of platforms range from 130 to 80 degrees, with an average of 118 degrees. The weights range from 167 gm. to 6 gm., with an average of 49 gm. (Fig. IV 13).

3. Analysis and Replication

Technology

The raw materials that were selected to make these stone tools included chert (86%) and volcanic rock (14%). There is cortex on 28 specimens (76%). Most of the cortex is smooth with a curved surface. This smooth curved surface

suggests a source of raw material that very possibly originated from nodules, not from the rock stratum. The sizes of these nodules were quite different. The length/breadth/thickness measurements of the core tools range from 121x78x32 mm. to 36x40x24 mm., with an average of 64x67x43 mm. These numbers indicate that the raw material nodules from which the cores were obtained were similar in length and breadth, and that the flintknapping usually started with and worked on the longer side of the nodule. Therefore, the average of the tool breadths is greater than the average length. The core tools are comparatively thick. The weights of the core specimens range from 1,500 gm. to 39 gm., with an average of 362 gm.

There are 28 specimens retaining cortex, the percentage of the cortex ranges from 5 per cent (cortex present only on the platform), to 50 per cent with an average of 20 per cent. The number of flake scars on the cores ranges from 22 to 4, with an average of 9. This number suggests that flintknappers fully utilized each raw material source to produce flakes or to sharpen the edges. There are 10 core specimens in the study, 7 were produced unifacially, and 3 were made bifacially.

There are 27 flake specimens. The length/breadth/thickness measurements of the flakes range from 108x164x44 mm. to 26x18x8 mm., with an average of 60x54x22 mm. There are 15 (55%) flakes with length greater

than breadth, 7 (26%) for which the breadth is greater than the length, and 5 (19%) with breadth and length similar. All the flake specimens in this study retain their platforms, but 3 of the platform angles are not measureable. Platform thicknesses range from 46 mm. to 0.8 mm., with an average of 16 mm. The platform breadths range from 158 mm. to 2 mm., with an average of 39 mm. The ratio of the thickness to the breadth of the platform is 1:2.4. There are 4 (15%) specimens (see P5303, P5366, P3953 and P5256) that retain cortex on the entire platform. On specimens P3957 and P4274 flat negative flake scars were used as platforms, and there are no retouching scars on the platforms of these specimens. The platforms of P5271, P5354, P3890, P5297, and P3959 were certainly prepared before these flakes were taken off. The average number of flake scars on the prepared platform is 3. This number may indicate that platform preparation was not a very complicated process. Most of the specimens show various flake scars on the back edges of the platform, which result from trimming the proximal edge. For example, there is cortex and one flake scar on the original platform of P3951, and there are 4 additional small retouching scars from dorsal face to ventral on the back edge of the platform to form a proximal working edge. The platform angles range from 130 to 80 degrees, with an average of 119 degrees.

There are 16 (80%) flake specimens that are made unifacially. Two of them (P5366, P5312) are flaked from dorsal face to ventral; nine of them are flaked from ventral face to dorsal. The other five are flaked from opposite directions between the different edges: between two lateral edges (see P5271 and P3957), and between the proximal edge and distal edge (see P5289, P3890, and P5277). There are 4 (20%) flake specimens that are made bifacially. The weights of the flake specimens range from 1,000 gm. to 4 gm., with an average of 114 gm.

The shapes of the stone specimens of Guanyindong are not regular. One characteristic of the technology is continuous use of free-hand hard hammer percussion to form several working edges on each tool; there are at least two to three working edges on most of the tools. The numbers of trimming scars on the flake tools range from 33 to 6, with an average of 16. The secondary retouch on each edge is also continuous, but sometimes there are two or three directions of trimming on one edge (see, for example, the concave edge of P5271). The angles of the working edges range from 24 to 90 degrees, most of them are over 75 degrees (these edges are not very sharp). The trimming scars are erratic: some are large and shallow; some are steep and small. The result is that the tool edges are not very even, and there are more concave edges than usual. The ratio of flake specimens and core specimens in the present

sample is about 3:1 (this number is similar to the ratio of flake tools and core tools in Group B from the excavation).

Selection of Lithic Raw Material

There was rice growing on the depression in front of the cave, so I could not find any rocks on the surface. I located a map of the Rock Stratum Distribution which was made by the Office of the General Survey of Soil in 1983. This map presents basic information about geological features of the area, and I started my survey according to the features described on this map. In the area 5 km east of the cave, there are rocks around several coal mine shafts. The outer surfaces of the rocks are dark gray, but when you break them, they are light grey inside. They are limestone, and the dark coloring comes from the coal. There is limestone everywhere, but this was not the raw material that the Guanyindong people chose to make stone tools, probably because it is too brittle. This is demonstrated today by the chipped and broken limestone along the pathways, the result of people or animals walking across them.

To the south of the cave about 10 km is the Liouchun branch of the Wu River. The river bed is 200-400 m lower than the terraces of the river. There is some chert sandwiched between the two layers of limestone. This chert layer is about 10-20 cm thick. Although there are

impurities in the chert, and it looks different from the chert of the Guanyindong industry, it is suitable for flintknapping. The layer is too thin to have been used to create the tools of the Guanyindong industry, however.

To the west of the cave, about 6.5 km, I came into an area of quartzite. It was very different from the environment around the cave. The large bed rock was all exposed. There is a village here named Huashi. About 8 km north of Huashi is Jinyan hill (26 degrees north by east of the cave). Around Jinyan there is a natural reservoir whose water comes from a stream. During the rainy season, the water level is high and the river flows very rapidly. The stream is in a gully, which now has furrows for sowing crops. Some of the furrows are boulder-strewn. The straight distance from Jinyan hill to the cave is 4.15 km (Fig. IV 14). There are, at present, chert nodules around the stream, the gully, and the hill. These chert nodules appear similar to those used by prehistoric people at Guanyindong.

I collected 150 kilograms of chert nodules from Jinyan (this sample was only half of the nodules that the local people collected for me; Fig. IV 15). The chert nodules are irregular in shape, and each differs from the others. Most of the nodules are covered by a thin layer of cortex. I measured about 50 nodules: the length/breadth/thickness measurements range from 226x168x146 mm. to 95x80x57 mm.,

with an average of 170x130x101 mm (Fig. IV 16). This average number is much larger than the average measurements of core specimens (64x67x43 mm), and flake specimens (60x54x20 mm). There are two possible explanations for this difference: one, as noted earlier, is that flintknappers of Guanyindong cave fully utilized each piece of raw material (the average number of flake scars on cores is 9). After producing a certain number of flakes, the size of the core would be reduced substantially. Another reason is that the quality of the chert nodules satisfies the essential requirements for each piece of raw material producing a large number of flakes. The weights of these nodules range from 6,500 gm. to 800 gm., with an average of 2,500 gm. The hammerstones selected are solid, elliptical nodules, easy to hold (Fig. IV 17). I measured 10 hammerstones. The length/breadth/thickness measurements range from 172x150x14 mm. to 80x70x42 mm., with an average of 116x80x62 mm. The weights of hammerstones range from 4,350 gm. to 600 gm., with an average of 1,985 gm.

Reduction Sequence

All replicated specimens were produced with hard hammer direct percussion, using my left thigh to support the stone. I had to use two to three different sizes of hammerstones to replicate most of the specimens. In the beginning, I usually used a large hammerstone to break a large nodule

(the size of the hammerstone was still smaller than the raw material of the specimens, however). Sometimes the hammerstone broke in half. Using this method to produce the flakes (even accidentally) means that the large nodule on the thigh functions as a hammering block or anvil, the hammer in the hand functions as another block; could this be a block-on-block technique? In fact, the broken flakes of the hammerstone were easy to trim into flake tools. This might be the reason why there were no hammerstones found in the collections of the Guan Yin Dong: most hammerstones were eventually broken up by use. Because the hammerstones and the artifacts were in the same raw material, it is difficult for us to identify the original functions of each.

There are 6 (60%) core specimens that are Core with unifacial edges in other shapes, there is edge damage present on them. These cores are the end results of flake production. I would say in this particular industry that these cores were for the production of thick flakes. If the original nodule had a flat natural face that could serve as a platform, the reduction sequence could be easily started from there, and flakes could be taken off from two or three sides of the core (see P4119, and P4117). Then people could use these waste cores from which to detach other flakes. If the original nodule did not have a platform (see P4116, P4114, and P5255), the first step should be to take off a large flake to form a flat surface. then to use the

resulting negative flake scar as a platform to rough-out the flakes. If necessary, the platform could be retrimmed for use in producing more flakes. The result of this reduction produces many thick flakes that differ in shape. The cores are roughly cone shaped, like P4116 and P4117 (Fig. IV 19).

Specimen (P4266) belongs to a type of Core with one bifacial leaf-shaped end (the original report called this tool a semi-handaxe). Because the shapes of the nodules that were used as raw material are quite thick and block-shaped (the average length/breadth/thickness measurements are 170x130x101 mm.), there are not many nodules that can qualify as this type. I made a small type [C13] specimen (Fig. IV 20), and tried to separate the flakes into three stages of manufacture: first, roughing-out, removal of protrusions and disconformities of the raw material. This first stage can employ low and flat angles to remove thick flakes (Fig. IV 18). The second stage, thinning and shaping, is the thinning and removing of any bumps and the remaining cortex. The striking platforms are made with low angles, each platform has to be set up by each projection, taking flakes that are rather thin and longer than they are wide (Fig. IV 21). The third, finishing stage is the production of the correct shape and of sharp cutting edges by removing thin, and small flakes. The platforms of the first stage are thick and covered by cortex, those of the second stage are rather thin with partial cortex covering

and preparation, and those of the third stage are thinner, some of them coming close to the shape of a common pressure blade (these kinds of flakes can be seen on the flake specimens of the collection, such as P3946, P5257, and P5260). In replicating some bigger specimens (Fig. IV 22), I could divide the flakes into two groups: large and thick, and small and thin (Fig. IV 23).

As noted above, the nodules are quite thick and blocky. This shape not only limits the sizes of the tools, but also makes it easy to produce tools from flakes. No matter how heavy the raw material is, the length of the flake cannot be greater than the core diameter, and flakes that have sharp edges can easily be produced. I think that is why the artifacts from the cave have similar measurements: length/breadth are 30x50 mm, and 50x70 mm., and the flake specimens are 75% of the total specimens. The secondary retouch on the flakes is almost 90 degrees, and continues trimming into the central portions of the flakes. The result of this trimming is edges that are stronger and can be used longer.

From the reduction sequence we can see a definite pattern in the industry of Guanyindong. This pattern is directly related to the distance of the chert nodule resouce, which was 4.15 km. from the cave site. The fact that the Guanyindong flintknappers had to travel this distance to obtain the raw material for tool production

appears to have led them to make efficient and full use of each piece of the raw material to produce flakes. Moreover, the core tools and the flake tools are both end products and both apparently used. (I did not undertake edge wear analysis, but I base this claim on the fact that core tools and flake tools display similar edge damage). There are a number of clues seen in the production of both the flakes and cores: the average number of flake scars on the core specimens is 9; the average dimension of core specimens (64x67x43 mm.) is similar to the flake specimens (60x54x22 mm.); most core specimens were trimmed from different directions, using more than one platforms; there are 2.7 times the number of flakes as cores, and the edges of flakes were retouched intensively.

Chapter 6 Bose

In October 1973 the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), the Museum of the Guangxi Zhuang Autonomous Region, and the prospecting team of Guangxi Zhuang Autonomous Region investigated the paleontology of Bose Basin. They found a lithic locality at Shangsong village, Bose county (Li, 1975). Eleven stone specimens were excavated from the third terrace (red drift) of the You River. The specimens are sandstone and quartz.

The head of the IVPP team, Pei Wenzhong, described the Quaternary chronology in the caves of this region on the basis of mammalian fossils from the Guangxi area. He suggested that the deposits of "yellowish loam", very hard and iron cemented, belong to the Early Pleistocene; the deposits of "red drift" belong to the Middle or Late Pleistocene; and the deposits of the "grey clay", which contain many oyster and snail shells, belong to the Neolithic Age (Pei, 1965). Following Pei's view of this stratigraphic chronology, the excavators of Shangsong village suggested that the age of the third terrace is equivalent to the "red drift" deposits in the cave, and may be Late Pleistocene.

In 1960, Jia Lanpo also discussed the deposits in the Guangxi caves, based on IVPP investigations of 350 caves (Jia, 1960). The sequence runs as follows: the deposits that contain *Gigantopithecus* fauna most likely belong to the

Early Pleistocene (Q1); the deposits containing *Stegodon-Ailuropoda* fauna are those of the Middle Pleistocene (Q2); the deposits containing oyster and snail shells may belong to the Late Pleistocene (Q3); and the deposits that contain polished stone tools and other cultural remains may be Holocene (Q4). Unfortunately, as yet no mammal remains have been found associated with the stone artifacts on the terraces of the You River of Bose Basin. Therefore, the cave studies just noted can be used only for general reference.

In 1977, 1979, and 1982-1983, joint archaeological teams from the Bose Region Cultural Relics Museum, Guangxi Zhuang Autonomous Region Museum, and IVPP investigated Paleolithic remains around the Bose Basin. They collected about 2,000 Paleolithic stone specimens from three counties: Bose, Tiandong, and Tianyan. The three counties are on both sides of the You River. The stone specimens were found in over 100 localities on the surface of the third and fourth terraces (a few lithic specimens were uncovered by excavation, but there is no indication in the present collection of which artifacts these are). Most of the specimens are silicified limestone and vein quartz. Some mammalian fossils were also found, but not in association with the stone specimens.

In the winter of 1988, Huang Weiwen, Yuan Xiaofeng of the IVPP, and I went to Bose. With the support of the IVPP,

the Museum of Guangxi Zhuang Autonomous Region, and the Bose Museum of Cultural Relics, we carried out a small (36 square meters) excavation at Posuan village, Tiandong county. Sixty-nine stone specimens were unearthed from the primary laterite in the fourth terrace on the north bank of the You River. Although these stone specimens are few compared to the thousands collected from the surface, we believe that the majority of the Bose specimens derive from the laterite. Specimens collected in the past were usually exposed on the surface of the eroded laterite, and their technology and types are quite similar to those of the artifacts unearthed more recently (Huang, 1990).

Teilhard de Chardin, C.C. Young, and others paid special attention to the age of the laterite loam when they investigated the Cenozoic geology of Guangxi and Guangdong in the 1930s. They said: "To this period, which, south of the Tsinling (Qinling), is of just as much importance as a 'glacial period' in Western Europe or in North America, we shall give the name of `lateritic period', the Late Cenozoic being consequently divisible into: pre-lateritic sediments (primary laterites), and post-lateritic sediments (redeposited laterites, and ordinary loams)" (Chardin, 1935:188). Although this lateritic period started approximately at the end of the Late Pliocene erosional phase all over central and south China (this extended as far as the Zhoukoudian, Yinkou, Changtu, and Panshi, at

approximately 43 degree north latitude according to Liu, 1964), lateritization ceased before deposition of the Lower Pleistocene Red Loam in the northern Qinling. It may have lasted much longer in Guangxi south of the Qinling, however, perhaps even into the later part of the Lower Pleistocene or the early Middle Pleistocene (for further discussion, see Dating section below).

1. Geological and Archaeological Background

Location

Bose Basin, which is in the hilly area of Guangxi and Guangdong, is about 200 km northwest of Nanning city (Fig. V 1). It is 106.30-107.30 degrees east longitude, 23.30-23.60 degrees north latitude. The area extends from Bose city (northwest) to Siling city (southeast). The length of the basin is over 90 km., the width is over 15 km., and the area is about 800 square kilometers. The You River, a tributary of the Pearl River, passes through the central part of the Basin (Fig. V 2). The river valley was formed in the Tertiary period.

In the normal terrace sequence of the You River within the Bose Basin area, there should have been four terraces. Because Pleistocene erosion has only partially removed the laterites from the slopes, this "planation", or the filling in of the valleys with the sediments that were on the slopes, often results in missing terraces (most commonly one

or two) in different areas on both banks of the river. As expressed by their general morphology, these terraces may be described as follow:

1. The first terrace is 10-15 m. above the river bed, and is composed of a dark gray gravel layer and sandy clay. The terrain slopes gently and widely, most areas are covered by crops.

2. The second terrace is 15-25 m. above the river bed, and is composed of a grey and brown basal gravel layer and sandy clay. Most of this terrace has been eroded, forming a long series of low rolling hills.

3. The third terrace is 35-50 m. above the river bed, and is composed of a cemented brown basal gravel layer and red or yellow loam. There are few areas that still retain the wide terrace, a large part of the formation has probably been washed away and changed. Reconstruction or remodelling of the slopes has been caused by erosion of the red drifts, and there are also exposures of gravel.

4. The fourth terrace is 50-70 m. above the river bed. It is composed of a thick, gray basal gravel layer (13 m.) overlain by extremely lateritized clay (primary laterite). Some areas of this terrace have been eroded into large tablelands between the mountain peaks.

According to the original excavation or investigation reports, all the paleolithic tools were found in the third or fourth terraces. As noted above, topographic features

are quite complicated here, hence there are many arguments about the ages of the terraces, and about which terrace the tools come from. In the present study I concentrate on the specimens from the laterite terraces because the dating of these specimens is more secure. I discuss the dates of these locations below.

Stratigraphy

There are two parts of the excavations that could serve as stratigraphic type-sections: one is the section documented in 1973 at Shangsong village on the southern bank of the You River (Li, 1975), the other is the section recorded in 1988 at Posuan village on the northern bank of the You River (Huang, 1990). The Shangsong section is on the third terrace, 35 m. above the river bed. The deposits here are divided into 7 layers from top to bottom (Fig. V 3):

Pleistocene:

7. Red drift, no sub-layer, stone tools are present. The thickness is 6 m.

6. Loose brown gravel layer, with sandstone and shale pebbles, 2-5 cm. in diameter. Thickness is 0.2 m.

5. Red drift, fewer sands, stone tools are present. The thickness is 4 m.

4. Brown gravel layer, same as the layer 6. Thickness 0.2 m.

3. Red drift, thickness 6 m.

2. Brown gravel layer formed by Triassic sandstone and shale. These gravels are well rounded, the individual grains being 3 to 5 cm. in diameter, a few are 10 cm. in length. Thickness of the bed is 0.9 cm.

Dissection

Eocene:

1. Grey greenish sandy clay.

In the Pleistocene deposits described above, red drift and gravels alternate three times. These three cycles of sedimentation are similar, but the stone tools were found only in the 7th and the 5th layers.

The section of Posuan village is on the fourth terrace (buried terrace), 50-70 m. above the river bed. The deposit here is divided into 2 layers (Fig.V 4):

1. At the surface is lateritic sandy clay, an erosion slope soil, 10-25 cm. thick, overlying.

2a. Light brown clay with fewer gravels, which are usually 1.7-2.5 cm. in diameter, although some of them are 11.5-14 cm. in diameter. The gravels are well rounded sandstone, igneous rock, quartzite, and quartz. Thickness of 2a is 60-80 cm.

2b. Dark brown clay, containing ferric oxide and aluminium oxide net-veined lenses. The sediment is solid with red or white iron-cemented gravels. Thickness is 30 cm.

The stone tools may be as high as 50 cm. below the surface, but are concentrated around the 60-80 cm. depth, only a few of them being deeper than this. The color and the composition of the soil change gradually from 2a to 2b. Under 2b, there is a thick layer of gravel, which could be call 2c. These three sub-layers all belong to one period of river deposit. This is the "lateritic period" of de Chardin. Therefore, Huang believes the stone tool stratum belongs to the laterite (Huang, 1990).

Dating

There are no absolute dates for any site in the Bose area. But so far most of the paleolithic stone tools have been recovered from the lateritized stratum, or collected on the surface of the eroded laterite. Therefore, the date of these paleolithic tools must be directly related to the age of the "lateritic period".

According to the original discussion of the "lateritic period", the lateritization occurred after the deposition of old alluvial fan sediments (Late Pliocene), and before a Pleistocene series of sediments (Teilhard de Chardin, Young, and Pei, 1935). Most of the gravels of Guangxi belong to the "lateritized fan system". This long period of extremely wet and warm weather caused exposure and a deep weathering of the soil. Even the gravel layer of the Dagu glacial period was lateritized.

The age of the lateritized fans in Guangxi was compared to the "Yuhuatai Beds" of the Lower Yangtze River. Along the Yangtze River, the Yuhuatai basal gravels descend to the same level as that of the present low water, exactly as the sub-lateritic gravels of Guangxi, which they resemble in physiography and lithology. The Yuhuatai terraces have been recognized as probably belonging to the Late Pliocene (Barbour, Chardin and Bien, 1935). This provides circumstantial evidence for the age of the lateritized fans in Guangxi. Paleomagnetic dating of the lateritized terrace of the lower Yangtze River indicates that the red clay mixed with gravels of the Dagu glacial period dates to 0.9-1.1 my BP, and the red bed of the Dagu inter-glacial period dates to 0.8-0.9 my BP (Xing, 1989). Studies by soil scientists of the red weathered crust sequence of southern China also indicate that the red clay mixed with gravels is Lower Pleistocene in age (Q1); the thick base, which consists of red beds, is from the middle Pleistocene (Q2); and the homogeneous red clay is upper Pleistocene (Q3). The red weathered crusts cover almost the whole Quaternary period in southern China (2.5 - 0.1 my B.P.) (Xi, 1991).

The lateritized terrace was present not only in the Bose Basin of China, but also in several big rivers in the southern part of Asia, such as the Chao Phraya River in Thailand, and perhaps the Indus River in Pakistan. During winter of 1989, I visited an early Paleolithic locality in

the Central Lampang Province of northern Thailand. In 1984, three stone artifacts had been found here in a matrix of red laterite and fluviatile gravels, which stratigraphically underlie the Lampang basalt (Pope, 1986). The paleomagnetically reversed basalt flow yields K-Ar ages of 0.8 + 0.3 and 0.6 + 0.2 million years, which confirm the age of the lateritic period in northern Thailand. These data are in agreement with those on the lateritized terrace of the lower Yangtze River, and in southern China.

As we can see then, there were developmental stages in the "lateritic period". The Guangzhou Branch of the Institute of Geochemistry, Chinese Academy of Sciences, worked on the identification of the characteristics of the red soils of different stages by analytic methods of chemistry, electron microscopy, and X-ray diffraction (Zhu, 1991). Chemical composition and mineral associations of red soils were found to be different in each stage or each age. The indicators of each different stage in the "lateritic period" help us to identify the dates of the lateritized terraces and the climatic changes during the Quaternary. I regret that I am not yet able to use this method to date the lateritized terraces in Bose in which I found the artifacts included in this present study. I am limited to the use of neotectonics, geomorphology, and pleistocene paleoclimatology. In my excavation report of the site, entitled "Advanced Opinions on the Stratigraphy and

Chronology of Bose Stone Industry" (in Huang 1990), we suggest that the period of strong laterization in South Asia may be the early *Sinanthropus* period (Middle Pleistocene) dating back to about 600,000 - 400,000 years ago. The Bose artifacts of the laterized terrace may be equivalent to the Lantian period (late Early Pleistocene), dating back to about 1,000,000 to 730,000 years ago.

2. Description and Classification

Previous work

The earliest brief, but extensive survey of the Guangxi and Guangdong areas (in particular Guangxi) was by the Cenozoic Laboratory of the Geological Survey of China in 1935. Project members were trying to "establish a preliminary connection between the Cenozoic of the Yangtze and the Cenozoic of the most southern parts of China" (de Chardin, 1935:179). In the conclusion, they point out three features that characterize the area south of the Qinling Mountains during the Late Cenozoic: a Lower Pliocene lake-regime; a great Late Pliocene erosion, which was responsible for all the lateritized "boulder clays" sometimes interpreted as glacial deposits; and an extensive Final-Pliocene lateritization. This study is a very important beginning for geological research in China, expecially for establishing the ages of the large area of lateritized terraces in southern China.

In October 1975, Vertebrata Palasiatica published the first article about Paleolithic locality No. 73071 at Shangsong villege, Bose county (Li, 1975). Eleven fragments of silicified limestone and quartz artifacts were excavated from the third terrace of the You River. There are cores (4), a thick scraper (1), choppers (3), and points (3). The excavators state that the artifacts are basically core tools with unifacial edges, and are large and crude. Their provisional decision was that the locality belongs to the late Paleolithic period.

Zeng Qiangwang of the Regional Cultural Relics Museum has been working in the Bose area since 1977. He found 71 paleolithic localities and collected 1,500 pieces of stone specimens from the excavations and surfaces of the terraces (Zeng, 1983). These stone tools are silicified limestone rock, quartz, shale, and chert. These raw materials were drawn from the local lower gravel levels of the third and fourth terraces, and were made into points, choppers, and scrapers. Most of them are large core tools, which were flaked either unifacially (the usual technique) or -- occasionally -- bifacially. He believes that these lithic tools belong to the Paleolithic period.

In 1982, the Museum of Guangxi Zhuang Autonomous Region investigated the paleolithic remains in Bose county (He, 1987). They found 21 localities on the surface of the third and fourth terraces of You River. The total number of stone

specimens is 752 (546 pieces are stone tools). Most of them are made of siliceous rocks, quartzite, and vein quartz. There are points, chopper-chopping tools, and bifaces. These artifacts are considered to be typologically consistent with a Paleolithic date.

Excavation in the winter of 1988 was quite limited because the purpose of the work was to clarify the relationship between the third and fourth terraces. The location of the excavation is an open hilly area, which is one hundred miles away from the Posuan village on the second terrace (Fig. V 5). The background of the site is a large tableland between the mountain peaks. There are many stone specimens on the surface of the eroded laterite terrace. This landform is similar with most of the geographical features of the collected or excavated stone specimens in the area (Fig. V 7). The elevation of the site is 152 meters above sea level. The three test trenches are in the front (Ta), middle (Tb), and back (Tc) of the laterite terrace, which is either the fourth or the third. The area of each trench was 2.5x4 square meters (Fig. V 6). The surface soil was quite weathered, and contained plant roots. We began to find some small pebbles and debris from broken pebbles 40 cm below the present surface, and recovered several quartzite and sandstone specimens 50-90 cm below the surface. These included core tools, flakes, and chips that were made unifacially and bifacially. There are clearly

identifiable percussion bulbs on the proximal ends of the flakes. This suggests that these early toolmakers made their stone tools in this area. One point that should be noted, however, is the scarcity of flakes and chips in the collections. This may be because of the weathering and water movement on the open hilly area, the small specimens being transported and lost. The lateritized sediments of the strata provide evidence that the excavation terrace may indeed be the fourth terrace, and hence may be equivalent to the late Early Pleistocene or Middle Pleistocene.

The Collection

Until these materials are published in China, I cannot use the 69 pieces of stone artifacts unearthed from the primary laterite at the Posuan village. (The article I have used thus far, "Advanced Opinions of the Stratigraphy and Chronology of the Bose Stone Industry"; did not describe the stone artifacts we found from the excavation; the description will be published separately). I apologize for this lacuna, but it is necessary if I am to do future work in China.

The stone specimens from the Shangsong village (Locality 73071) are stored in the warehouse of the IVPP. Because these specimens have been dated to the late Paleolithic period by the original excavation report, I did not include them in my study. The 42 records I use here

were selected according to documentation of the locality (there are 13 localities), morphology of the specimens, and the approval of the museum of Guangxi Zhuang Autonomous Region. Most of them were collected from the surface of the fourth terrace, and their faces are red because they have been covered by lateritized soil for a long time. The names of the specimens written on the tools, correspond to the names of the villages, with the numbers being assigned by the investigator.

<u>Core with single unifacial edge [C1] (4 specimens)</u>

Specimen Dongzen 3 is made of a crude sandstone cobble, and specimens Chaimu 5, Tanhe 9, and Tanhe 5 are quartzite cobbles. The butt ends are rounded cortex; Dongzen 3, Chaimu 5, and Tanhe 5 show the pitting on the cortex. Chaimu 5 is made on a small, flat cobble. The cobble contains fine grains, the surface is quite smooth. The flake scars are one on top of the other on the long side of the cobble. The edge is sharp, and two deep negative flake scars form a projecting lip in the middle of the edge. The length/breadth/thickness measurements are 94x62x42 mm., the weight is 500 gm. (Fig. V 8).

Dongzen 3 is made from a nearly square, flat, weathered cobble. The edge/circumference ratio is 60 per cent. The flake scars are not even, some of them are flatter than the others. There are some small irregular chip scars on the

edge, also. The length/breadth/thickness measurements are 136x134x69 mm., the weight is 1,000 gm. (Fig. V 8).

Tanhe 9 is made from an egg shaped cobble. The edge/circumference ratio is only 27 per cent. The single edge on one side of the cobble tip is jagged and appears to be heavily damaged. The length/breadth/thickness measurements are 135x104x80 mm., the weight is 1,000 gm.

Tanhe 5 is made from a flat, ellipsoid cobble. The flake scars are on one end, they are even and flat. The single edge exhibits edge damage. The length/breadth/thickness measurements are 142x120x62 mm., the weight is 1,000 gm. (Fig. V 9).

Core with double unifacial edges [C2] (2 specimens)

Specimens of Chaimu 8 and Dongzen 4 are both made on large, flat, roughly rectangular cobbles. There is a point on the long end of each tool that is formed by double unifacial edges. Double edges are not of the same length, one is about twice as long as the other. The edge/circumference ratio is about 50 per cent. Both edges are jagged. The butts of the cobbles still retain their original shapes, and there is no damage present on the cortex. The length/breadth/thickness measurements of Chaimu 8 are 150x130x78 mm., of Dongzen 4 are 168x141x63 mm.; wight of Chaimu 8 is 2,000 gm. (Fig. V 10), of Dongzen 4 is 1,500 gm. (Fig. V 9).

Core with unifacial distal end perpendicular to both edges [C3] (2 specimens)

Chaimu 9 is made on a large, thick, square quartzite cobble. Chaimu 6 is made on a comparatively smaller, flat, roughly rectangular quartzite cobble. Both butt ends are rounded cortex in the original shapes. Two parallel longitudinal edges extend for nearly the whole length of either lateral side of the cobbles. On specimen Chaimu 9, these two parallel edges are made by one deep blow on either side, and form a high ridge piece in the center of the cross-section. On Chaimu 6, one lateral edge is formed by one deep blow, but the other shows several flake scars. The unifacial distal edge extends half way to the butt ends, and is made carefully on both samples. There is heavy edge damage present on the distal edges of both specimens. The length/breadth/thickness measurements of Chaimu 9 are 155x152x92 mm., of Chaimu 6 are 106x84x50 mm., and weight of Chaimu 9 is 2,000 gm. (Fig. V 10), of Chaimu 6 is 800 gm. (Fig. V 11)

Core with one unifacial leaf-shaped end [C5] (10 specimens)

There are 8 specimens (Chaimu 4, Chaimu 7, Tanhe 7, Tanhe 8, Tanhe 10, Damei 096, Dafa 59, and Damei 72) made of quartzite cobbles, one specimen (Shangsong 1) made on a quartz cobble, and one specimen (Tanhe 1) made on a

sandstone cobble. They are oblong and either roughly triangular or biconvex in cross-section. The butt ends are all rounded cortex. The distal ends are sharp, and tongue-shaped. Some of them such as Shangsong 1, are quite pointed (Fig. V 11). The lateral edges are even and symmetrical on most specimens. The point of the specimen Damei 072 is broken (Fig. V 12). The greatest numbers of flake scars are 15 (on Tanhe 7) (Fig. V 12), and 13 (on Tanhe 10) (Fig. V 13). The specimen with the fewest flake scars is Shangsong 1 (7). Other specimens with a low number of flake scars are; Chaimu 7, Tanhe 1, Tanhe 8, and Damei 096 (Figures V 13, V 14 and V 15). The least cortex remaining on the specimens is 50 per cent, for example see Chaimu 4, where the flaking face is almost covered by scars (Fig. V 17). The most cortex remaining on the specimens is 75 per cent, for example Tanhe 1 is worked only on the distal and lateral edges of the frontal area; the central part of the flaking face and back face are all covered with cortex. One lateral edge of Specimen Dafa 59 is convex, the flake scars extend to the end of the butt, and there are several weathering spots on both faces of the cortex (Fig. V 16). The location of the edge damage is different on the various specimens: Chaimu 4, and Tanhe 10 exhibit damage on the point area only; Damei 072 on the point, and cortex area; Shangsong 1, Tanhe 8, and Damei 096 only on the cortex area; Chaimu 7 only on one lateral edge; Tanhe 7 and Dafa 59 on the double

lateral edges; and Tanhe 1 on the double lateral edges and cortex area also. These edges are jagged. There is pitting on the cortex. The length/breadth/thickness ranges from 202x160x100 mm. to 126x98x52 mm., with an average of 165x123x71 mm.; the weight ranges from 2,300 gm. to 600 gm., with an average of 1,480 gm.

Core with all unifacial edges [C7] (4 specimens)

Specimens Dongzen 5 and Tanhe 3 are quartzite cobbles. Dongzen 2 and Dongzen 6 are larger, sandstone cobbles. In most of these specimens, the entire circumference is trimmed by irregular unifacial flaking. Dongzen 2 is made on a long cobble, the front view is rhomboid and oblong in profile. Both long ends of the tool are points. The flake scars are not even, most of the edges are steep, one edge is formed by flat scars extending to the central part of the tool. Edge damage is present on this edge only. The length/breadth/thickness measurements are 194x114x82 mm., the weight is 1,000 gm. (Fig. V 17).

Dongzen 5 and Dongzen 6 are both made on egg shaped cobbles. There is roughly 5 per cent of the edge still remaining on the cortex. The flake scars are larger and flatter on Dongzen 6 than Dongzen 5. There is edge damage present on all the edges of both. The length/breadth/thickness measurements of Dongzen 5 are 128x92x80 mm., of Dongzen 6 are 166x120x72 mm.; weight of

Dongzen 5 is 1,000 gm.(Fig. V 18), of Dongzen 6 is 1,200 gm. (Fig. V 19).

Tanhe 3 is made on a rounded cobble. The flake scars are an inclined plane extending to the central part of the lower face, the tool is approximately funnel shaped in profile. Edge damage is present on one side of the edge only. The length/breadth/thickness measurements are 148x124x78 mm., and weight is 1,200 gm. (Fig. V 18).

Core with double bifacial edges [C10] (1 specimen)

Specimen Nanzhao 3 is made on a triangular flat quartzite cobble. The bifacial edges are not only on the double lateral edges that formed the distal point, but also on the central ridge of the upper face. The butt is thick, and retains the cortex. There is edge damage present on one of the lateral edges only. The length/breadth/thickness measurements are 114x110x76 mm., weight is 1,000 gm. (Fig. V 19).

Core with one bifacial leaf-shaped end [C13] (8 specimens)

Specimen Tanhe 4 is made on a heavily weathered sandstone cobble, and the rest of the specimens are quartzite cobbles. Cortex surface remains on all the specimens, but some of them retain more than others. The one with the least remaining cortex is Tanhe 4 (5 per cent), which is trimmed around the entire circumference bifacially

(Fig. V 20). Yangwucun 007 retains only 8 per cent and was trimmed along both lateral edges (Fig. V 21). The rest of the specimens retain cortex surface around the butt. Most of the specimens are biconvex in cross-section, but the numbers of flakes are usually not the same on the upper and lower faces. Examples of this are the upper faces of the Specimens Datong 013 and Bose 10, which still retain partial cortex on their butts, but the lower faces are covered with flake scars (Figures V 22 and V 23).

Specimens Yangwucun 007, Baigu 005, and Yangwucun 018 are large symmetrical tools, the tips are sharp, and the profiles are long and narrow (Figures V 23 and V 24). On specimens Damei 143 and Dongzen 05, the trimming scars extend to the butt on one lateral edge of one face, the other lateral edge still retains entire or partial cortex (Fig. V 25). Edge damage is present on different locations on these specimens: on the single lateral edge of Datong 013 and Yangwucun 007; on the double lateral edges of Baigu 005; and on the points of Tanhe 4 and Bose 10. There is multi-damage present on some other specimens: on the point and double lateral edges of Yangwucun 018; on the point and one edge of Damei 143; and on one edge and cortex of Dongzen 05. The length/breadth/thickness measurements range from 215x126x70 mm. to 130x104x74 mm., with an average of 168x120x72 mm., the weight ranges from 2,000 gm. to 500 gm. with an average of 1,425 gm.

Core with bifacial edges in other shapes [C16] (1 specimen)

Specimen Tanhe 6 is made on a half-rounded sandstone cobble. The upper face of the core is flat and full of flake scars. These were struck off by the removal of flakes from the entire circumference of the round edge of the upper surface. Then using this flat face as a platform, flakes were taken off on one side of the core vertically. These elongated flake scars on the side of the core are roughly parallel. The other sides of the core are still covered by cortex. The tool profile is cone shaped, and there is edge damage present on the round edge of the upper face. The length/breadth/thickness measurements are 124x114x78 mm., the weight is 1,000 gm. (Fig. V 26).

Core tool in other shapes [C17] (1 specimen)

Tanhe 11 is made on a roughly rounded cobble. There are irregular flake scars randomly distributed over two faces of the core, and the flake scars are large and shallow. There is cortex covering one-third of the surface. There is edge damage present on one single edge only. The length/breadth/thickness measurements are 102x102x90 mm., the weight is 1,000 gm. (Fig. V 26).

Flake with double lateral unifacial edges [F2] (1 specimen)

Specimen Baigu 53 is made on a large, thin, rectangular quartzite flake. There are two flake scars on the platform that formed a crest down the middle of the platform. The bulb of percussion is under this crest, which indicates that the flake was struck off from this point. The trimming scars on both lateral edges are uneven, one lateral edge is sharper than the other. The retouch on both lateral edges is from ventral face to dorsal. The breadth of the distal edge is greater than that of the proximal end. About 20 per cent of the cortex remains on the lower part of the dorsal face, and the distal edge is jagged. The length/breadth/thickness measurements are 186x145x48 mm., the thickness and breadth of the platform are 48 and 85 mm., the angle of the platform is 114 degrees, and the weight is 1,000 gm. (Fig. V 27).

Flake with unifacial leaf-shaped distal end [F5] (1 specimen)

Specimen Dongzen 1 is made on an oblong, thin sandstone flake. The tool is broken in two, and there are new damage marks on the broken edges. There is a natural break mark along one lateral edge of the dorsal surface that made this edge sharper. Cortex covers the other lateral edge, and the trimming scars are concentrated on this edge that runs from the dorsal face to the ventral. The tongue-shaped distal

end is trimmed evenly. The original proximal end is missing, hence measurement of the thickness, breadth, and angle of the platform are not possible. There are flake scars on the proximal surface, which are made from ventral face to dorsal, so it is unclear how large a piece of the proximal end has been broken off. There is edge damage present on the single lateral edge, which is carefully trimmed. The present length/breadth/thickness measurements are 224x139x44 mm., and the weight is 1,800 gm (Fig. V 28).

Flake with single lateral bifacial edge [F12] (1 specimen)

Specimen Nanposhan 1 is made on a small, kidney shaped quartzite cobble. A side of the distal end has a natural fracture. There is cortex on the platform and distal part of the dorsal face. The bifacial trimming scars are not even, and there is damage on the edge. The length/breadth/thickness measurements are 135x94x51 mm., the thickness and breadth of the platform are 31 and 55 mm., the angle of the platform is 110 degrees, and the weight is 900 gm. (Fig. V 28).

Flake with bifacial leaf-shaped distal end [F16] (4 specimens)

Specimens Chaimu 1 and Lioufen 02 are made on sandstone flakes. Dongsun 03 and Nazhao 01 are quartzite flakes. There is one flake scar on the platform of Dongsun 03, the

platforms on the other specimens retain the cortex. Chaimu 1 is made on an oblong flake. The distal edge is almost perpendicular to the double lateral edges, and this area is carefully trimmed. The platform is the thickest part of the flake, and is the only area that still retains cortex. There is edge damage present on the double lateral edges. The length/breadth/thickness measurements are 194x112x60 mm., the thickness and breadth of the platform are 60 and 79 mm., respectively the angle of the platform is 122 degrees, and the weight is 1,000 gm. (Fig. V 29).

Lioufen 02 is made on a large, thick flake. Cortex remains on 25 per cent of the dorsal face. The ventral face is quite flat, and the bulb of percussion is not very clear. The trimming scars are concentrated on the distal area; they are even, and form a sharp distal edge. There is edge damage present on the double lateral edges. The length/breadth/thickness measurements are 230x170x74 mm., the thickness/breadth of the platform is 74x143 mm., the angle of the platform is 105 degrees, and the weight is 2,800 gm. (Fig. V 30).

Dongsun 03 is made on a long, roughly triangular flake. The cortex remains on only 10 per cent of the specimen, on part of the platform; the rest of the circumference is trimmed bifacially. The trimming scars are not even, there are crack marks on both faces. The thickest part of the tool is the central portion, and there is edge damage

present on the double lateral edges. The length/breadth/thickness measurements are 183x157x76 mm., the thickness and breadth of the platform are 40x95 mm., the angle of the platform is 114 degrees, and the weight is 1,000 gm. (Fig. V 31).

Nazhao 01 is made on a comparatively smaller flake. A flake had been taken off the original cobble previously, so the dorsal face is almost flat and there is no cortex. The ventral face is nearly parallel to the dorsal face on the proximal part, and the bifacial trimming is on the distal part of both lateral edges and the distal edge. The distal edge is flat and sharp, and shows edge damage marks. The length/breadth/thickness measurements are 150x124x64 mm., the thickness and breadth of the platform is 64x120 mm., the angle of the platform is 96 degrees, and the weight is 1,000 gm. (Fig. V 32).

Unmodified flake [U1] (2 specimens)

Both specimens are made on quartzite flakes. Chaimu 2 is a long, narrow flake. There are three flake scars on the platform indicating its preparation. The dorsal face retains cortex. Both the lateral and distal edges are naturally sharp. There is edge damage present on the double lateral edges. Length/breadth/thickness measurements are 148x90x45 mm., the thickness and breadth of the platform are

45 and 85 mm., the angle of the platform is 134 degrees, and the weight is 900 gm. (Fig. V 33).

Tanhe 2 is a wide flake whose breadth is greater than the length. There are several flake scars on the dorsal face that had been taken off the original cobble previously. Cortex remains on the proximal end, one lateral, and the distal end. The other lateral is a naturally sharp edge and has edge damage marks. The length/breadth/thickness measurements are 114x124x58 mm., the thickness and breadth of the platform are 41 and 60 mm., the angle of the platform is 128 degrees, and the weight is 1,000 gm (Fig. V 33).

3. Analysis and Replication

Technology

The raw materials selected to make these stone tools include quartzite (72%), sandstone (26%), and quartz (2%). About half of the specimens are weathered on the surfaces, the rest are in fresh condition..

The length/breadth/thickness measurements of the core tools range from 215x126x70 mm. to 94x62x42 mm., with an average of 153x118x72 mm. These numbers indicate a ratio of length:breadth:thickness equal to 2.1:1.6:1, meaning that most of the tools are oblong. The weights of the core specimens range from 2,300 gm. to 500 gm., with an average of 1,345 gm.

The percentage of cortex on the cores and flakes ranges from 5 to 80 per cent, with an average of 46 per cent. There are 33 core specimens in the collection, about 79 per cent of the whole. This ratio of cores to flakes may be the true proportion between core and flake specimens from the Bose area. Core specimens predominate in the excavations and on the surface. The number of flake scars on cores ranges from 5 to 21, with an average of 9.5. There are 10 core tools made bifacially, 23 were produced unifacially.

There are 9 flake specimens. The length/breadth/thickness measurements range from 230x170x74 mm. to 114x124x58 mm., with an average of 174x128x58 mm. There is only one specimen, Tanhe 2 (11%), in which the breadth is greater than the length; for the rest of the specimens length is greater than breadth. Except for specimen Dongzen 1, whose platform was removed during production, all the specimens retain their platforms. Cortex remains over the entire platforms of the 5 specimens (63%). There are 2 flake scars on the platform of Baigu 53, and Dongsun 03, and 3 flake scars on the platform of Chaimu 2. These three platforms were prepared before the flakes were taken off. The percentage of platform preparation is not high in this industry, and there are no retouching scars on the platforms of these specimens. Platform thickness ranges from 74 mm. to 31 mm,, with an average of 50 mm. Platform breadth ranges from 143 mm. to 55 mm., with an

average of 90 mm. The ratio of the thickness to the breadth of the platform is 1:1.8. The weights of the flake specimens range from 2,800 gm. to 900 gm., with an average of 1,267 gm. Comparing the average weights and sizes of the flakes to the cores in the study, we can see that there is not much difference between the two. This indicates that the flakes that have been used here to make tools were usually large. These flakes were made to be used as tools, they were the end-products of the tool making process and were not the by-products of tool making. The large flakes in the present study were not trimmed from the cores in the sample studied, they were made directly from large cobbles. The smaller flakes that were trimmed from the cobbles to produce large core tools were lost in the secondary deposit or in some other manner. The ratio of flake specimens and core specimens in the present sample is about 1:2.7. This number represents the collections I have seen in several localities of the Bose area.

There are 2 specimens that are made unifacially: Baigu 53 is flaked from ventral face to dorsal, whereas Dongzen 1 is flaked from the opposite directions: the distal and two lateral edges are made from dorsal face to ventral, but the proximal end is made from ventral face to dorsal. The other 5 flake specimens are made bifacially, the number of flake scars on the dorsal face ranging from 9 to 5, with an average of 7, on the ventral face ranging from 12 to 4, with

an average of 8. The platform angles range from 134 to 96 degrees, with an average of 115 degrees.

Within the retouched artifacts, 15 (38%) were made bifacially, 7 are the type Core with one bifacial leaf-shaped end, and 4 are the type Flake with bifacial leaf-shaped distal end. The percentage of this technology is higher than in any of the other archaeological localities discussed here for southern China. This unusual phenomenon has drawn much attention since it was first discovered in 1973 (Huang, 1987). In Huang Weiwen's article, "Bifaces in China", he points out that this kind of tool is present together with chopper-chopping tools, unifacial heavy pointed tools, and cleavers. These industries contrast with the other types such as the *Sinanthropus* and Guanyindong industries, in which a high percentage of the smaller size flakes are retouched to produce scrapers and points.

Selection of Lithic Raw Material

Cobbles of silicified limestone and quartz cobbles are found everywhere next to the You River (Fig. V 34). Because there are many small rifts in the earth's crust around the hills, one can see the exposed sections of the strike fault (Fig. V 35). There are cobbles in the gravel layers mixed with sands, and it is very easy to collect these cobbles. I can understand why there are so many Paleolithic localities on the surface of the third and fourth terraces of the You

River (Fig. V 36). The availability of the raw material, which is widely distributed in this area, makes possible a relatively dense distribution of occupational or knapping localities (Fig. V 37). These prehistoric people could produce the stone tools they felt they needed anytime and anywhere. They did not have to carry `tool kits' around, nor save tools to use later; therefore, tool size was not a major consideration. This is seen in the fact the tools here are large. The technology involved in the making of these tools was a simple one, which also helps to explain the large numbers of surface artifacts.

I collected 50 cobbles from the Nanposhan (a hill on the third terrace, Fig. V 38), which is not far from the Bose county seat. I also looked through the 1,400 piece collection of cobbles from the Cultural Relics Museum of Bose (these cobbles were sent to Bose as "artifacts" by the National Museum). The cobbles are in various sizes and colors, but most of them are roughly oblong. The particular characteristic of the raw materials here is that about 60 per cent of the cobbles are very weathered, and cannot be used to make stone tools. But this is not apparent from the surfaces of the cobbles; the only way to find out whether a cobble can be used or not is to knock off a flake and examine the inside of the cobble. The weights of these cobbles range from 500 gm. to 7,000 gm., with an average of 2,305 gm. The hammerstones selected were solid, elliptical,

quartz and quartzite cobbles (Fig. V 39). The weights of these hammerstones (n=10) range from 1,500 gm. to 400 gm., with an average of 750 gm. The hammerstones that I used here are not at all heavy. The length/breadth/thickness of the cobbles range from 260x180x90 mm. to 157x130x36 mm., with an average of 202x136x73 mm.

Reduction Sequence

In this flintknapping work I was helped by Huang Weiwen and Yuan Xiaofen. At Nanpo hill, we tried to use the same raw materials, at the same time, but with two different techniques. I used hard hammer direct percussion technique, Yuan used block on block technique. The purpose of this was to compare the differences between flakes produced by the different techniques. Freehand, hammer percussion does not demand very strict conditions for the shapes of the cobbles to be used. But the technique of block on block usually requires a flat surface on the cobble and on the anvil block, and a certain length of the locale to be used as a platform. Because there would be differences in the angles of holding the cobbles, I thought that there should be differences in the bulbs of the broken flakes: using the stone hammer technique would make a bigger and more protruding bulb than one that was made by block on block technique, whereas the block on block technique should produce a flake with a comparatively flat bulb. But there

was actually not much to distinguish the two in the shapes of the bulbs. There were differences in the sizes of the flakes, however. Flakes made by the block on block technique were smaller than those struck off with a hammerstone. Also, in block on block technique the widths of flakes are usually greater than their lengths. I think the block on block technique requires more strength and is a more sophisticated technique, because it is more difficult to control the shape of the core tool in the hand.

I present one account of the experimental work here as an example of the block on block technique. The length/breadth/thickness measurements of the cobble are 198x142x84 mm., the weight is 2,800 gm. The cobble is wide and oblong. The experimental work started at 5:00 P.M. and finished at 5:05 P.M. Seven small pieces of debitage, plus 7 flakes, were produced by this work. The type of the finishing core tool was Core with one unifacial leaf-shaped end. The length/breadth/thickness measurements are 190x142x84 mm., the weight is 1,300 gm. (Fig. V 40). For 5 of the flakes breadth is greater than length, for 2 length is greater than breadth. The edge of the tool is left jagged by the production process. Ten of the ancient specimens in my study are the type Core with one unifacial leaf-shaped end. When I compare this replication work with the artifacts, I cannot rule out the possibility that some of the latter were made by block on block technique.

On the other hand, it is not difficult to make a type of Core with one unifacial leaf-shaped end by hard hammer free hand percussion. I include a record of replication work as a example of this. The length/breadth/thickness measurements of the original cobble were 158x130x60 mm., the weight was 1,200 gm. The surface of the cobble is very smooth, and the color is gray, the inside color being darker and close to black. The replication started at 10:00 A.M., and finished at 10:06 A.M. There were 28 small fragments of debitage produced, and 8 flakes saved. There are 4 flakes with breadth greater than length, and 4 with length greater than breadth. The length/breadth/thickness measurements of the core tool are 136x90x48 mm., the weight is 400 gm.(Fig. V 41). The edge of the tool is very sharp with some jaggedness. A comparison with the ancient specimens included in my study suggests that the freehand, hard hammer technique was surely employed by the prehistoric Bose people. The results also indicate that free hand percussion produces more small debitage fragments than does the block on block technique.

Eight specimens in the study are the type Core with one bifacial leaf-shaped end. After producing the type Core with one unifacial leaf-shaped end, it is not difficult to work on the edge alternately to replicate the bifacial edges. I replicated 10 of this type of tools: some of them still retain a big butt with cortex (Fig. V 42); some of

them have both lateral edges extending to the end of the butt (Fig. V 43); and some of them have the entire circumference trimmed bifacially (Fig. V 44). There is no standardization in what kind of cobbles could be trimmed by how much. But there should be a pattern because people usually stop knapping for one of two reasons: first, when they have succeeded in producing the tool they desire, even if this means modifying only a specific part or edge; second, when they have exhausted all available platforms. In the second case, the tools are usually used for multiple functions. One can use the edges, points, or the smooth surface.

I did not produce many large flakes. This work requires a substantial amount of strength and usually wastes many cobbles to get one good, large flake. Some of the silicified limestone cobbles here are comparatively easier to break into flakes, however (Fig. V 45). After taking the flakes off, the core part can be trimmed into a core tool.

The result of the experimental work, with ready access to the raw material and simple free hand technique explains the proliferation of the stone tools at these localities. Added to this equation is the fact that the raw material, large silicified limestone cobbles, has very good working characteristics enabling the flintknappers to produce large flakes and uniform unifacial and bifacial leaf-shaped points.

Chapter 7 Bhimbetka

The site of Bhimbetka (the name is the colloquial form of the Hindi name Bhimbaithka) is located on the northern margin of the Vindhyan hills in the Raisen district of Madhya Pradesh of India (Fig. VI 1). The significant feature of the hills is a chain of sedimentary rock, which has been weathered to form shallow caves and rock shelters of various sizes (Fig. VI 2). There are over 1,000 such caves and shelters in the hills. More than 700 of the shelters contain paintings on their walls and ceilings. The Bhimbetka hills are well-known in India because of this high concentration of prehistoric paintings. These paintings are under the control of the Archaeology Survey of India, and permission to investigate them appears to be difficult to obtain. When I applied to the area's director of the Central Circle of Archaeology Survey of India for permission to work at the cave site, I had to explain that my work had nothing to do with the prehistoric paintings.

Prof. V.N. Mishra of Deccan college told me that Bhimbeka is the only site in India that has produced a continuous cultural sequence from Acheulean to Mesolithic in undisturbed contexts (personal communication, January 1989). This series of cave sites with early lithic materials was discovered by Dr. V.C. Wakankar in 1958; under his supervision the Vikram University of Ujjain undertook excavation in 1972. Because Dr. V.C. Wakankar died before

he was able to finish the formal excavation report on Bhimbetka, all of his excavation materials were stored (unprotected) on the roof of the museum of the Vikram University. The exposed artifacts covered an entire section of the roof, and were grouped by layers and types (Fig. VI 3). These artifacts excavated from cave IIIF-24, IIB-33; and shelters IIIA-29, IIIA-30. There are approximately two thousand artifacts in the collection. The present director of the museum Dr. D.S. Solanki (Wakankar's student) told me he intends to finish this work for Wakankar.

From 1972-78, Mishra of Deccan College worked in collaboration with Vikram University. A large scale excavation was conducted in IIIF-23, where 52 sq m were dug inside the shelter. The stone tool industry recovered consists of 4,737 artifacts (Mishra, 1978). Mishra published several articles about the preliminary study of this excavation, and one of his students at Deccan College is currently working on the formal excavation report on Bhimbetka.

1. Geological and Archaeological Background

Location

The site of Bhimbetka is 45 km southeast of Bhopal city, and 2 km south of Bhianpur. It lies at 22.50 degrees north latitude, 76.37 east longitude. The Bhimbetka hills run in an east-west direction. They are 1 km long, half a

km. broad, and lie over 100 m above the level of the surrounding plain (650 m above the sea level). The hills are thickly covered by deciduous forest. Because of the rock art, Bhimbetka is a tourist attraction. There are routes for visitors that lead up from the bottom of the hills to the top, and even between the rock shelters (Fig. VI 4). The hills are a short hike by foot from the road.

The Narmada River is on the southern side of the Bhimbetka hills. In good weather, one can see the broad Narmada Valley about 25 km away (Fig. VI 4). It runs northwest to southeast on the south side of the hill. The valley is quite deep and surely functioned as a drainage for a long time. The Betwa River is parallel to the Narmada River north of the hills, 20 km away. There is no stream close to Bhimbetka today, but there are several natural springs nearby that are the current sources of water for the local people.

The Bhimbetka shelters have been divided into seven groups based on their locations: I, II, III, etc. from east to west. Each of these groups has been sub-divided into A, B, C, etc. sub-groups, and each shelter has been assigned an Arabic number. All this information is written on the walls of each shelter. I mainly worked on materials previously excavated from the two largest rock shelters: IIIF-23, and IIIF-24. Both shelters have a broad, high frontage but taper to a small cross-section at the back (Fig. VI 5).

Rock shelter IIIF-24 is 40 m long, 4-12 m broad and 6-15 m high. The trenches form the 1970s excavations are still partially open, but one can see that the original surface was nearly level. These shelters contain paintings on both walls and ceilings.

Stratigraphy

There are four sections from rock shelters IIIF-23 and IIIF-24 deposits that have been published, but I refer to only two of them here. One is Trench II, the Palaeolithic levels of Bhimbetka IIIF-24 in Wakankar's 1972 excavation. Here Wakankar's work provided significant information for the present study, namely that "in the lowest level is the lateritic soils which has yielded several pebble tools. The deposit is covered by huge weathered boulders and reddish black soil probably formed due to weathering and humus. This 60 cms thick layer is a sterile layer and no tools were obtained from it" (Wakankar, 1972:26). While Wakankar observed no tools in the layer immediately above the pebble tool laterite, above this sterile layer, he found an Acheulian floor, (Floor I). Therefore, there were two different industries in the cultural squence: a pebble tool industry and an Acheulian industry. The layer containing Acheulian tools is on top of the layer containing the pebble tools, and there is a 60 cm. thick layer which contains no tools between these two tool industries.

The second section is the one between trenches F&G (facing east) of Bhimbetka IIIF-23 in the excavation of 1973-75 by Mishra. According to Mishra, shelter IIIF-23 has yielded the thickest occupation deposit of all excavations. He found that "the Bhimbetka Acheulian industry is characterized by a very low perentage of bifaces, high proportion of cleavers to handaxes, a remarkably high standard of workmanship in bifaces, especially cleavers, predominance and great diversity of non-biface tools, high percentages of end scrapers and Levallois flakes, and complete absence of chopper-chopping tools" (Mishra, 1975:27). In spite of these marked typological differences between IIIf-23 and IIIf-24, Mishra thinks that "material from Trench II (IIIF-24) shows it to be technologically fairly similar to that from III F-23" (Mishra, 1975:29).

From the perspective of my study, I would have liked to work with the collections from both these rock shelters, but due to time constraints and other limitations I was able to work only with the artifacts from the IIIF-24 shelter, which are in the collections at the museum of Vikram University. My goal was to see whether I could define an evolutionary sequence of technologies from the chopper-chopping pebble tools to the Acheulian industry. If I could do this, it might help elucidate the nature of the relations between these two different techniques in the Narmada region.

The deposits of Trench II (3x2 m) in IIIF-24 are more than 2.7 meters thick, and are divided into 7 layers (Fig. VI 6; Wakankar, 1973:31).

Layers 1 and 2. information not given, probably disturbed surface.

3. Smaller chips and yellow ochre soil (muddy appearance). Middle Palaeolithic.

4. Same as above but bright yellow ochre. Middle Palaeolithic.

5A. Yellow ochre, Acheulian floor II, 110 cm depth. Lower Palaeolithic.

5B. Big boulders with light red, soil-like deposit, 175 cm depth. Lower Palaeolithic.

5C. Red soil and weathered boulders, Acheulian floor I, 210 cm depth. Lower Palaeolithic.

6. Reddish black soil huge boulder, 270 cm depth. No tools.

7. Lateritic deposit, weathered boulders, chopper like pebble tools (the depth is not given). Lower Palaeolithic.

The deposits of Trenches F&G of Bhimbetka IIIF-23 are about 3 meters thick, and are divided into 8 layers (Fig. VI 7; Mishra, 1975:17).

1. Dull yellowish brown, soft silty sand, poor in clay content; contains geometric microlithic industry and small

quantities of grey ceramics and rare bone pieces. 5-10 cm thick.

2. Dull yellowish brown, slightly darker in color and finer in composition than layer 1, and more microlithic than layer 1. 10-25 cm thick.

3. Brown, more sandy than layer 2; there are thin, weathered, reddish stone chips over the layer. 10-20 cm thick.

4. Dull brown, more clayey, and rock fragments, late Middle Palaeolithic or Upper Palaeolithic industry. 15-20 cm thick.

5. Dull reddish brown, finer sediment is silty sand; typical Middle Palaeolithic industry. 40-50 cm thick.

6. Bright reddish brown, stone blocks larger; late Acheulian industry. 80-90 cm thick.

7. Bright reddish brown, more reddish and far more compact than layer 6, more deeply weathered; late Acheulian industry. 90-100 cm thick.

8. Orange, very little fine transported sediment, no cultural materials in the lower 30 cm; late Acheulian industry. 80-90 cm thick.

Rock shelter IIIF-24 is adjacent to shelter IIIF-23, and the above two sections of the trenches are only about 20 meters apart. In general, there should not be a big difference in the cultural deposits. But below the Acheulian layer in Trench II of IIIF-24 there was a 60 cm

thick sterile layer, and underneath it a lateritic deposit that "yielded several pebble tools" (Wakankar, 1973:26). The lateritic deposits with chopper-like pebble tools and 60 cm. sterile layer were not found in the lowest layer of shelter IIIF-23. Hence, there apparently was a difference in the cultural deposits between these two locations. The problem confronting us is how to explain this difference.

Dating

There was no evidence of organic remains associated with the stone industry from the Palaeolithic level in shelter IIIF- 23 and IIIF-24. There is no absolute dating yet available for the Lower Palaeolithic period. We must rely upon relative dating for the Lower Palaeolithic artifacts in the study. According to the original report, the deposits in rock shelters IIIF-23 and IIIF-24 at Bhimbetka were undisturbed, and the artifacts were collected during a scientific excavation. There are several radiocarbon dates available for the Mesolithic period, ranging from 8,000 to 2,000 B.P. (Nagar, 1983). Hence, 8,000 B.P. is an approximate upper limit for the Palaeolithic occupation deposits.

Classification of the Lower and Middle Palaeolithic tools in the preliminary study was done using Francois Bordes' (1961) typology for Acheulian industries. Mishra

thinks that this system appears to serve well for the Bhimbetka material of India as well as for Europe.

There were 1 meter thick Lower Palaeolithic deposits directly beneath 1.1 meters of Middle Palaeolithic deposits at Trench II, IIIF-24. There was not much difference in the percentage of smaller flakes and bigger flakes between the Middle Palaeolithic (686 pieces; 74%) and Lower Palaeolithic (789 pieces; 77%). But the percent of discoidal cores and scrapers is greater in the Middle Palaeolithic (221 pieces; 24%) than in the Lower Palaeolithic (117 pieces; 12%). The clearest evidence of differentiating traits are the ovates, handaxes, and cleavers, which were absent in the Middle Palaeolithic collections but constituted 123 pieces, or 12 per cent of the Lower Palaeolithic assemblage. The pebble tools were found only in the lowest level at a depth below 2.7 meters. In this study, I refer only to the artifacts of the Lower Palaeolithic period below 110 cm. in Tr. II of IIIF-24 shelter.

2. Description and Classification

Previous work

A preliminary report about the excavations of Trenches I & II in Cave IIIF-24 in 1972 was published in 1973 (Wakankar, 1973). This report states that these rock-shelters were first occupied during the Early Stone Age. Pebble tools and an Acheulian industry were found, with the

tools made of quartzite cobble and sandstone. Two floor levels where Acheulian tool makers left tools and flakes lying in situ and covered by a layer of rocks in the excavations were identified. Wakankar believes that revealing Lower Paleolithic living floors with in situ cultural remains is particularly significant.

When I visited the museum of Vikram University, I found a poster size diagram on the wall next to the Bhimbetka exhibition titled "Development of Biface (Handaxes) from Pebble Tools". This drawing of a local biface industry developing from earlier pebble tools was made by Wakankar (Figure 10), based on tools he found from Bhimbetka, but he presents it as an abstract sequence that could have happened anywhere.

Another preliminary study of rock shelter IIIF-23 at Bhimbetka was published in 1975 (Mishra, 1975; a similar version of this article was published in the journal *Australian Archaeology* in 1978). The excavation took place over 3 seasons (235 days) in an area of 52 sq m inside the shelter. In this report, there are tables listing the vertical distributions of major artifact classes in the Acheulian deposits. The artifact types are flake tools (1326 pieces; 28.05%), handaxes (40 pieces; 0.85%), handaxe fragments (15 pieces; 0.32%), cleavers (97 pieces; 2.05 %), cleaver fragments (53 pieces; 1.12 %), flakes (2,864 pieces; 60.39 %), cores (159 pieces; 3.36 %), and debris (183

pieces; 3.87 %). There is a detailed summary of the typological and technological industry analyses. Mishra points out that the Bhimbetka Acheulian industry is characterized by end scrapers, Levallois flakes, a very low percentage of bifaces, a high proportion of cleavers, and a complete absence of chopper-chopping tools. The raw materials used were basically two kinds of quartzite (sandstone, see Appendix A): dark purple and yellowish, the first richer in iron content and more intensely metamorphosed, making it tougher and more resistant to weathering than the second one. Because the ratio of cores and waste flakes to finished tools in purple quartzite is much lower than in yellowish quartzite within the shelter, Mishra believes that the purple quartzite was quarried some distance away and the tools were manufactured near the source of the raw material. The yellowish quartzite was from the shelter or next to the shelter, so the people used this to make tools within the shelter.

In 1983, Malti Nagar of Deccan College published an article titled "Man and Environment". Using the view of early economic adaptation to plains and hill-forest ecology, Nagar seeks to explain autochthonous population changes in the Bhimbetka region. Nagar also uses ethnographic information from four villages located close to Bhimbetka, and she suggests that "the tribal inhabitants of these villages are cultural (and most probably also biological)

descendants of the prehistoric rock shelter dwellers" (Nagar, 1983:64). She bases her findings on the examples of the exploitation of wild plant foods, scavenging, and use of various types of traps and snares rather than guns for hunting. This kind of reconstruction which traces the development of prehistoric people of an area to their descendants provides a model of a more or less continuous occupation.

Most articles that have been published about Bhimbetka discuss the rock paintings. Because it is difficult to date this rock art or judge claims as to whether or not it belongs to the early Palaeolithic period, I do not use these publications in my study.

The Collection

There are about 1,020 stone tools from the excavation of Trench II, IIIF-24 at Vikram University (Fig. VI 8). These artifacts were laid out in 7 rows and 8 columns on the roof of the museum in a manner that reflects the original excavation report: 7 layers at Trench II, and 8 types (Discoidal cores, Bigger flakes, Small flakes, Hallow scrapers, Side scrapers, Ovates, and Handaxes), as classified by Wakankar in 1972. Each type of tool was placed in a pile along a column, and each pile was arranged according to layer (row). Each pile has a thin layer of dust and when I moved one tool from the pile, there was a

sun-bleached pattern around the tool. From this observation and from personal communication with the museum director, it appears that no one has moved these tools since they were first classified back in 1972. Of these I was permitted to work on only 13 pieces. These 13 specimens include one or two typical pieces from each pile of tools in Period Ia: Pebble Tool Industry, and Period Ib: Acheulian Industry, as classified by Wakankar (Table 6). So, these specimens basically represent the original types of the collection. These two units, Ia and Ib, belong to the Lower Palaeolithic, but there was a 60 cm thick reddish black sediment containing huge boulders separating the two industries. Unfortunately, there were no excavation identification numbers on any of the tools; hence, to those I was allowed to record I assigned an arabic number as well as the Ia or Ib designation. For example, I listed the specimens from Ia (Pebble Tool Industry) as Ia:1, Ia:2, ... to Ia:8; the specimens from Ib (Acheulian Industry) continued as Ib:9, Ib:10 ... to Ib:13.

<u>Core with single unifacial edge [C1] (1 specimen)</u>

Specimen Ia:3 is made from half of a large, flat, quartzite cobble. The original cobble might have been broken into two parts, the face of the natural fracture is flat. The tool is in fresh condition. There are two flake scars at one extremity, and there are pitting marks along

the cortex of one length of the side, which is transverse to the broken side. Cortex covers almost all of the tool's two faces. The length/breadth/thickness measurements are 152x83x38 mm., the weight is 800 gm. (Fig. VI 9).

Core with single bifacial edge [C9] (3 specimens)

Specimen Ia:1 is made on a thick sandstone cobble, and specimens Ia:2, and Ia:4 are made from quartzite cobbles. Each specimen retains 50 per cent of cortex, and the surfaces are weathered in different degrees. The single edge of each specimen is made bifacially; the edges are comparatively sharp with some damage.

The surface of specimen Ia:1 is deeply weathered, and has some calcium cemented material on it. The edge/circumference ratio is 2:3, the trimming area is comparatively big. Because the cobble is thick, the trimming scars on both faces are steep. This edge is jagged. The length/breadth/thickness measurements are 116x90x72 mm., the weight is 1,200 gm. (Fig. VI 9).

Specimen Ia:2 like Ia:1, is made on a small round cobble. The edge/circumference ratio is almost 1:2. The upper face is trimmed steeply, and there are two layers of flake scars, one on top of the other. This edge is jagged. The length/breadth/thickness measurements are 90x68x56 mm., the weight is 300 gm. (Fig. VI 9).

Specimen Ia:4 is made on a flat, roughly square cobble. The flake scars are large and shallow on both faces, and the single edge is a little dull. The edge/circumference ratio is 2:3. The length/breadth/thickness measurements are 121x121x70 mm., the weight is 1,000 gm. (Fig. VI 10).

Core with one bifacial leaf-shaped end [C13] (2 specimens)

Both specimens are made on sandstone blocks, and they are similar in size. There is no cortex on either specimen. The bifacial trimming extends along the entire circumference, the tip part is substantially more pointed than the butt. Most of the flaking is bold, with relatively large scars. Both specimens are thin biconvex in cross-section, with longitudinal irregular ridges formed by the intersection of the trimming scars on either edge. The edges are generally sharp with heavy edge damage. The length/breadth/thickness measurements of Ia:7 are 154x92x48 mm., of Ia:8 are 152x92x46 mm., the weight of Ia:7 is 800 gm. (Fig. VI 10), of Ia:8 is 700 gm. (Fig. VI 11).

Core with two bifacial leaf-shaped ends [C14] (1 specimen)

Specimen Ib:10 is made on an oblong, thin sandstone block. The working edges are basically bifacially trimmed, but part of one lateral edge is not trimmed on both faces. The flaking scars are not even, and cover only the edge area. They do not extend to the central part of either

face. The cross-section is irregular biconvex. The trimmed extremity is more sharply pointed than the opposite end, which is relatively thin and broad. The edge is jagged with damage. There is no remaining cortex. The length/breadth/thickness measurements are 152x86x40 mm., the weight is 700 gm. (Fig. VI 11).

Core with all bifacial edges [C15] (1 specimen)

Specimen Ib:9 is made on a thick, rounded quartzite cobble. There is cortex on the central part of the upper face, the flaking scars are not even, and are distributed around the edge. The flake scars are irregular in size, and fully cover the lower face. The profile is symmetrically biconvex; one extremity is sharper than the opposite end. The edges are jagged and continuous around the entire circumference. Length/breadth/thickness measurements are 118x112x74 mm., the weight is 1,100 gm. (Fig. VI 12).

Core tool in other shapes [C17] (1 specimen)

Specimen Ia:6 is made from an almost rounded sandstone cobble. The profile is egg shaped. The flake scars cover the entire surface of the tool, with no cortex remaining. The surface is weathered, with some calcium cemented material on top. The trimming scars are not even, some are deeper than others. There is pitting on all the faces. The

length/breadth/thickness measurements are 106x96x92 mm., and the weight is 1,100 gm. (Fig. VI 12).

Flake with unifacial distal end perpendicular to double lateral edges [F3] (1 specimen)

Specimen Ib:11 is made from a thin sandstone flake. The bulbs of percussion present under the ridge of two flake scars nearly touch each other on the platform. The butt is relatively massive and the specimen diminishes gradually in thickness to a thin, slightly spatulate distal edge. The shape of the tool is roughly rectangular. There are trimming scars on the distal and both lateral edges of the ventral face. Three large, shallow flake scars on the dorsal face indicate that the proximal end was deliberately thinned. Both lateral edges are sharp, but jagged from damage. The length/breadth/thickness measurements are 123x70x32 mm., the thickness and breadth of the platform are 18x70 mm., the angle of the platform is 120 degrees, the weight is 500 gm. (Fig. VI 13).

Flake with unifacial leaf-shaped distal end [F5] (1 specimen)

Specimen Ia:5 is made on a small sandstone flake. There is no cortex, but there is some calcium cemented material on the dorsal face. The trimming has been done carefully around the entire edge, leaving a lozenge shaped,

flat unworked surface on the middle part of the dorsal face. The flake scars are basically even. There are three flake scars on the ventral face, which were taken off next to the platform to sharpen the edge. The bulb of percussion is under the ridge of the two flake scars that nearly touch each other on the platform. The tip is pointed and the butt is rounded; the tool is comparatively thick. There is edge damage on all the edges. The length/breadth/thickness measurements are 72x40x24 mm., the thickness and breadth of the platform are 19x35 mm., the angle of the platform is 135 degrees, and the weight is 120 gm. (Fig. VI 13).

Flake with double lateral bifacial edges [F13] (1 specimen)

Specimen Ib:12 is made on a thin, rather large sandstone flake. The breadth of the distal end is greater than the proximal end. There is a longitudinal dorsal ridge formed by the intersection of the trimming scars on either edge, but the flake scars are not even. Both lateral edges are trimmed bifacially, the edges are sharp and jagged. The bulb of percussion is not clear at all, so it is difficult to be precise about the location of the platform, which is flat with no flake scar. The length/breadth/thickness measurements are 145x100x30 mm., the thickness and breadth of the platform are 19x54 mm., the angle of the platform is 110 degrees, the weight is 500 gm. (Fig. VI 14).

Flake with bifacial leaf-shaped distal end [F16] (1 specimen)

Specimen Ib:13 is made on a large sandstone flake. The tool is symmetrically shaped, the edges are entirely bifacially trimmed. The flake scars are large and shallow. There is a flat, unworked surface in the central portion of both the dorsal and ventral faces. The edges are sharp, with irregular curves. There is no flaking scar on the platform. From the profile section, one can see that the platform and distal edges are thinner than the middle. The length/breadth/thickness measurements are 170x108x46 mm., the thickness and breadth of the platform are 46x92 mm., the angle of the platform is 140 degrees; the weight is 1,900 gm. (Fig. VI 14).

3. Analysis and Replication

Technology

The raw materials that were selected to make these 13 stone tools included sandstone (9 pieces, 69%) and quartzite (4 pieces, 31%). There is cortex on all the quartzite tools, ranging from 17 to 90 percent, with an average of 52 per cent. There is only one sandstone tool (F-24 TR II Ia:1 [C9]) with remaining cortex (50%).

It is difficult to recognize the cortex on the sandstone material. The weathering rind of the sandstone rock leaves some sandstone material darker on the outside

than the inside, while others are the reverse. The only place where reliable observations can be made is the previously unworked portion. Sometimes I am not sure whether or not this unworked portion is the cortex. Therefore, I try to be cautious, and to note whether there is an unworked area on the tool.

There are 9 core specimens in the collection (70%). This percentage is far from the true proportion between core and flake specimens in Trench II, however. According to Mishra, the proportion of flakes is much higher than that of cores. He says, "it is surprising that while there are 789 (76.68 per cent) big and small flakes, there are only 4 (0.39 per cent) cores" in the waste products (Mishra, 1975:29).

The length/breadth/thickness measurements of the core tools range from 154x92x48 mm. to 90x68x56 mm.,with an average of 129x93x60 mm. In order to distinguish the two kinds of raw materials in core tools, I give two sets of measurments, one for each kind of material. The averages of the length/breadth/thickness measurements of quartzite tools (4 specimens) are 120x96x60 mm.,of sandstone tools (5 specimens) are 136x91x60 mm. The only significant figures are the length/breadth ratios: for quartzite tools the ratio is 1.25:1, whereas that same ratio for sandstone tools is 1.5:1. In general, the sandstone tools are comparatively longer and narrower than the quartzite tools. This is

because the quartize tools are made from cobbles, whereas the sandstone tools have been from blocks or flakes quarried from outcroppings. The average thickness for both kinds of materials is the same. The weights of the core specimens range from 1,200 gm. to 300 gm., with an average of 856 gm. The number of flake scars on the core specimens ranges from 23 to 2, with an average of 14. This number suggests that in most cases flintknappers fully utilized each piece of the raw material. Of the 9 core tools in the study, only 2 were produced unifacially.

There are 4 flake specimens in the study sample. The length/breadth/thickness measurements range from 170x108x46 mm. to 72x40x24 mm., with an average of 128x80x33 mm. All specimens are longer than wide. The platform thicknesses range from 46 to 18 mm., with an average of 26 mm; the platform breadths range from 92 to 35 mm., with an average of 63 mm. The ratio of thickness to breadth of platform is 1:2.4. There are two flake scars on the platforms of Ia:5 and Ib:11, respectively. In both cases, the bulb of percussion is under the ridge where two flake scars join. This may be a pattern of platform preparation. On two other flakes, flat flake scars were used as platforms. The weights range from 1,900 to 120 gm., with an average of 755 gm. Except for the fact that the flake tools are much thinner than the core tools (1:1.8), there is not much difference in average weights and sizes of cores and flakes.

This indicates that the flakes used here to make tools were usually large, and were the end-product of the tool making process.

There are 2 flake specimens that are made unifacially: Ia:5 is flaked from the ventral face to dorsal, Ib:11 is flaked from dorsal face to ventral. Two other specimens are made bifacially. The platform angles range from 140 to 110 degrees, with an average of 126 degrees, a rather large number indicating most flake platforms were prepared before being taken off from the outcropping.

There are 4 core tools in the study collection that are made from quartzite cobbles: 3 of them are from layer Ia, and 1 is from Ib. There are no flake tools made from quartzite. Only 1 quartzite tool is made unifacially (Ia:3 [C1]), 3 of them are made bifacially (Ia:2 [C9], Ia:4 [C9], and Ib:9 [C16]). The rest of the specimens are made from sandstone flakes or blocks: 5 of them are from the Ia layer, and 4 of them from Ib. There are 3 that are made unifacially (Ia:6 [C17], Ib:11 [F3], and Ia:5 [F5]), and 6 that are made bifacially (Ia:1 [C9], Ia:7 [C13], Ia:8 [C13], Ib:10 [C14], Ib:12 [F14], and Ib:13 [F17]). Overall, three of four unifacially made tools are from the Ia layer and only one is from the Ib layer. Hence, it appears that there is no positive correlation between quartzite material and the unifacial technique, but there may be a relation between the unifacial technique and the Ia layer. About 75 per cent

of unifacially made tools are from the lower layer, and they are made from quartzite or sandstone.

Selection of Lithic Raw Material

As noted, there is a chain of discontinuous monolithic rocks on the top of the Bhimbetka hills. These rocks, which form the local hills, are orthoquartzite or metamorphosed sandstone. The source of the raw material for ancient flintknappers could be at, or near, the rock shelter in which they lived. Today one still can see that the rocks on the hills have suffered different degrees of weathering, some of them being darker than the others (Fig. VI 15). I did not find many pebbles or cobbles on the hills, only some heavily weathered pieces that are rolled and somewhat rounded (Fig. VI 16). The quartzite cobbles that were found in TR II must have come from the nearest stream at that time.

I found many large outcroppings of sandstone. Local people have taken big flakes and chunks from them, so there are many flake marks on the surfaces (Fig. VI 17). I was much impressed by this recent work. I did not see what kind of knapping tool was used, but I did see the surface of the large core (an outcrop) retaining the flake scars and protruding striking points (Fig. VI 18). These marks showed that the flakes were struck by metal hammers. The flakes or blocks, which were used to surface the road, were of various

sizes (Fig. VI 18). They all have thick, flat platforms because the original outcroppings were mostly angular. Some of the flake platforms are triangular.

I collected and measured about 50 flakes and blocks some 150 to 50 meters from the rock shelters on the hills. The length/breadth/thickness measurements range from 200x240x69 mm. to 162x134x38 mm., with an average of 179x189x54 mm. Because most of these blocks or flakes have flat, wide platforms, about 60 per cent of materials I collected were wider than they were long. This average is much larger than the average measurements for core specimens (129x93x60 mm.) and flake specimens (128x80x33 mm.) from the archaeological site. The reason for this difference may be that the ancient flintkappers of Bhimbetka fully utilized each piece of raw material (the average number of flake scars on each core specimen is 14). Taking off this many flakes substantially reduces the size of the raw material core. The weights of these raw materials range from 4,000 gm. to 1,100 gm., with an average of 2,100 gm.

It was not easy to find good hammerstones. One must find some weathered and rolled pieces to provide several smooth surfaces for working. In general, these pieces of raw material are not strong enough to serve as hammers. I used 7 hammerstones to finish the work. The length/breadth/thickness measurements range from 153x144x85 mm. to 68x65x65 mm., with an average of 107x94x75 mm. The

weights of the hammerstones range from 1,500 to 600 gm., with an average of 890 gm. (Fig. VI 19).

Reduction Sequence

From the depths of the striking points remaining on the surface of the outcroppings, I can see the local people must have used a large metal hammer to remove the flakes. I also tried to take flakes from the outcroppings using a stone hammer, but succeeded in removing only some small pieces. One reason may be due to my level of strength, but the more important reason is probably that the hammerstones I used were too small for taking off a big chunk of material. Therefore, I just used the flakes and blocks available to start my replication work. I used hard hammer direct percussion. I did not use soft hammer because it was not necessary. But, depending upon the hardness of the raw materials, soft hammer technique could be used for the final retouching of a tool.

I present an account of the experimental work here as an example of using a large flake to make a type of <u>Flake with unifacial distal end perpendicular to double lateral edges [F3]</u>. The length/breadth/thickness measurements of the original flake were 200x240x69 mm., the weight was 4,000 gm. The breadth is greater than the length, and the distal end is wider than the platform. The bulb of percussion is on the side of the platform. The distal end is massive and

semicircular. There are several large flake scars that traverse the dorsal face. The first step was to take the flakes off unifacially around the distal end in order to sharpen the distal edge (Fig. VI 21). Then, I unifacially trimmed both lateral edges parallel to each other and almost perpendicular to the distal edge. The measurements of the finished tool are 141x90x60 mm., weight is 1,400 gm. A total of 33 flakes were taken off, 10 of them were debitage (too small to save). This is important in helping us understand why most specimens from the excavation were longer than they were wide, but 60 per cent of the raw materials are wider than they are long. Flintkappers usually concentrate on trimming both lateral edges, which reduces the breadth much more than the length.

In most instances of the replication work, the original flakes were thinner and smaller than in the above example. One can simply trim both lateral edges parallel to each other unifacially or bifacially, sometimes the distal end may be sharpened to a point (Fig. VI 22). If the raw material is a thick block, it is easy to trim the entire edge by alternately striking dorsal and ventral faces to form an `s' shaped edge, making a tool like the type of <u>Flake (or Core) with bifacial leaf-shaped end</u>. This is the fastest way to get sharp edges and a point (Figures VI 24 and VI 23). Specimen Ia:6 is a type of <u>Core with all bifacial edges [C15]</u> in rounded shape. For replicating this

tool, I chose a thick square block as the raw material, then alternately trimmed both faces towards the central portion of the block, ending with a sharp, bifacial, circular edge. Cortex remains on the central portion of both faces (Fig. VI 25).

Unit Ia, which contained some pebble tools, should be stratigraphically earlier than Unit Ib, the "Acheulian layer". But the 60 cm. sterile layer between the reported pebble tool and earliest Achuelian units at IIIF-24 precludes the possibility of a continuous occupation. The fact that there was no pebble tool layer in shelter IIIF-23 suggests that the pebble tool makers confined their occupation to shelter IIIF-24.

As noted, of the 9 core tools in the study, 7 (78%) were assigned to Unit Ia, and only 2 (22%) are from Unit Ib. Of the 4 flake tools, 3 (75%) were from Unit Ib, and only 1 (25%) was from Unit Ia. These numbers, if representative, indicate that the flintknappers of the Ia Unit preferred to use cobbles, and the somewhat rounded and rolled stones that were weathered blocks to make core tools. The quartzite cobbles, which do not appear later, must have come from the nearest stream at that time. These earliest Bhimbetka flintknappers were opportunistic, and apparently did not quarry raw material from the large sandstone rocks nearby. But the flintknappers of the Ib Unit certainly quarried raw materials from such outcroppings, either nearby or some

distance away. Hence, they were able to manufacture many more flake tools.

Why did the flintknappers of Units Ia and Ib use different raw materials for their manufactured stone tools ? I think that the cobbles and weathered blocks were expediently chosen by Ia group people. But, I am not sure why the Ib group people did not choose the same raw materials as the Ia group. There are several possible explanations. The first possibility is that the cobbles and rolled, weathered blocks used by the Ia group were gone by Ib time, or at least not enough remained for use. There are several ways this raw material resource could have been buried and it is certainly not available today.

The second possibility is that the toolmakers, in developing their technology, found that the quarried raw materials from the outcrops could make better tools. In fact, these reasons are connected: if there were raw materials ready to use and easy to use, then these raw materials would always be the flintknapper's first choice. Quarrying raw materials from outcrops takes more time, greater strength, better hammerstones, and more skill to set the platforms. After one has a certain type of raw material, the resulting technology for toolmaking is determined by the shape or form of that raw material. For example, if one uses flat cobbles or rolled weathered blocks as raw material, one can get a sharp edge more quickly by

unifacial flaking than bifacial flaking. This is probably why 75 per cent of the tools from the Lower layer (Ia) were unifacially made. There were many differences in the choice of raw material (expediently chosen cobbles and weathered blocks in Ia, vs. quarried sandstone outcroppings in Ib) and in manufacturing technique (unifacial core tools predominate in Ia whereas bifacial flake tools predominate in Ib) between these two periods. In spite of all differences, there were no transitional forms in typology between these two groups. Hence, I do not believe there was an evolutionary sequence from pebble tools to handaxes in Bhimbetka.

Chapter 8 Durkadi

Dr. Jorge Armand of the Universidad de los Andes, Merida, Venezuela, excavated the Durkadi Nala, India, in 1971. This work was undertaken as his Ph.D fieldwork. A number of scholars have praised Armand's work: Professor H.D. Sankalia (past director of Deccan College) affirmed Armand's achievement, especially his method of excavation. Sankalia pointed out that "not only the excavation was horizontal, but so contextual that the position of every flake or pebble tool was noted" (Sankalia, 1983: Forward). In the same book, Sankalia also noted that Professor F. Bordes had said that Armand's study is a valid and promising method for a primitive industry at a low level of typological specification. Professor S. Mishra of Deccan College reviewed Armand's book and suggested that "this is one of the few well documented Lower Paleolithic assemblages and its full publication in an accessible form is a valuable resource for Indian Paleolithic archaeologists (Mishra, 1986:161).

After I arrived at Durkadi Nala, I began to feel a great respect for Armand's work. This is not only because, under arduous conditions, Armand's method of excavation in the field was exacting and complete, but also because he did this work in spite of the malaria he struggled with during the period of excavation. Armand lost 10 kilograms during

the four months of excavation. He was unable to write the report of his research when he was in India, and for a long time he could not get enough money to go back to Venezuela. This might be one of the reasons that he did not publish his book "Archaeological Excavations in Durkadi Nala: An Early Paleolithic Pebble-Tool Workshop in Central India" until 1983.

Some of the artifacts from the Durkadi excavation were on exhibition in the Deccan College Museum in 1989. This archaeological site attracted my attention because it suggested the possibility of a local development of the handaxe from the chopper stage, and because the closest affinity tc the Durkadian artifacts is in the Early Choukoudian of China. The specimens in the Durkadi exhibition looked like those from the collections I studied in southern China.

1. Geological and Archaeological Background

Location

Durkadi Nala site is on the south bank of the Narmada River, in the state of Madhya Pradesh, about 2.5 kilometers southeast of Maheshwar villege. It lies at 22.9 degrees north latitude, 75.36 degrees east longitude (Fig. VII 1).

The area belongs to the Deccan Trap, which covers a large part of peninsular India. The Durkadi Nala is a tributary stream of the lower Narmada River, which is the

second largest river in India. It crosses the country from the mountains of Amarkantak to the western coast of the Arabian sea, flowing a total of 1,000 kilometers. Because the river flows across the center of the country, it has acted as a geographical and historical natural boundary between northern and southern India. In the Durkadi area, the Narmada River is about 500 meters broad. According to Armand's observation, there are three fluvial terraces towards the southern bank of the river: Terrace 1 or upper terrace (15 meters high and 2 km. broad), Terrace 2 or middle terrace (10 meters high and 1.2 km. broad), and Terrace 3 or lower terrace (5 meters high and 300 meters broad). There is a plateau that extends higher than Terrace 1, the plateau is about 20 meters high and several hundred kilometers broad (Fig. VII 2). The heights of these terraces were defined in relation to the present bottom of the Narmada River.

There have been serious doubts about the presence of distinctive terrace levels in the area. Mishra of Deccan college, after observations during fieldwork in 1980-81 and 1984, pointed out that the gravel resting on bedrock shows no discontinuity with the gravel on Terraces 2 and 1 (Mishra, 1986). Geomorphologist, S.N. Rajaguru of Deccan College told me that there are no terraces in central India, the land was very stable there. He claims that this is because the rivers meander across their valleys, cutting and

building alluvial deposits and then recutting the same deposit and building new ones (personal communication, Jan. 1989). I also discussed this issue with Paddayya, who suggested that there are terraces, but that dating cannot be derived from them. These deposits rest on the eroded surfaces of local rock formations and consist of cycles of gravel and silt/clay deposits. They either lie one upon the other or rest against one other, thus forming distinct terraces (personal communication, Jan. 1989). The results of excavation in the area may help in settling the above differences of opinion.

In order to discover the entire natural and cultural sequence of these terraces, Armand set up a system of 11 trenches (1.5x1.5 meters) parallel to the Narmada River. Terrace 3, in fact, is a part of the present river channel, which is partially covered by water during the rainy season. There is a deposit of coarse gravel, 1,500x300 meters in area, which rests directly on the bed-rock and extends around the mouth of the Durkadi brook and downsteam (the quartzite cobbles or pebbles on this terrace were used for replication work in the field). Two trenches (1 and 2) were excavated on Terrace 2, neither of which reached bed-rock. These do not contain quartzite pebble artifacts, but rather chalcedony, chert, and jasper flake artifacts. Armand's hypothesis relates these to the Middle Paleolithic period. Four trenches (8-11) were excavated on the plateau, but no

cultural remains were found, nor were there any signs of erosion that could explain the absence of cultural remains in the plateau. The only excavation trenches relevant to the present study are numbers 3 through 7 located in Terrace 1. Lower Paleolithic artifacts made of quartzite cobbles were found only in the coarse gravel layer. Armand suggests that Terrace 1 belongs to the Middle Pleistocene (Fig. VII 3). Therefore, I use only the excavation results of Trenches 3-7 on Terrace 1 in the study. Terrace 1 is about 2 kilometers south of the Narmada's present banks. It is located between the first and second waterfall of the Durkadi Nala. Five trenches were excavated near the front edge of Terrace 1.

Stratigraphy

According to the excavation report, there is a layer of coarse gravel resting on the bedrock in trenches 3, 5, and 6 (this layer is absent in trench 4, and trench 7 was not dug down to bedrock). The thickness of the gravel layer varies from 0.5 (trench 6) to 1.3 (trench 3) meters. On top of the coarse gravel layer is a layer of silt. The thickness of the silt deposit ranges from 1 m (in trenches 5, 6), to 6 m (in trench 7). There is a thin layer of black sediment (it is called humus in India) overlying the silt deposit in some trenches (numbers 3,4, and 5). On the very top, the deposit becomes sandy in trenches 5 and 6.

From the excavation, Armand found that the pebble artifacts were either rolled or very fresh. In order to clarify whether these two kinds of artifacts were from different stratigraphic levels, he excavated the coarse gravel layer of Trench 5 using hands as the main digging instruments (the rest of the excavation was done by small tools such as pocket knives and brushes). Armand noted that the results from this special trench confirmed that "the rolled artifacts occur in any level of the coarse pebble gravel, while fresh artifacts occur only within the top 35 centimeters of this gravel" (Armand, 1983:20). The top 35 centimeters of the coarse pebble gravel are cemented by calcium carbonate; below this level the matrix of the gravel is composed of coarse sand (Fig. VII 4). This phenomenon suggested the conclusion that the fresh, pebble artifact-bearing gravel of Terrace 1 had been sealed.

The stratigraphy of Trenches 2, 3, 4, and 5 was published in detail in the final report. Because Trench 5 was excavated with extra care, I refer to that section here. The Trench 5 deposit is about 2 meters thick, and is divided into 4 layers (Fig. VII 5).

1. Dark sand or black soil, which is 9 to 34 cm. thick.

2. Light red brown silt, sterile, which is 100 to 126 cm. thick.

3. Coarse pebble gravel, the top 35 cm. of which is cemented and retained 75% of the quartzite pebble artifacts

are fresh. The deposit below the top 35 cm. is not cemented, and all specimens are rolled. Both levels belong to the Lower Paleolithic, which is 50 to 80 cm. thick.

4. Basalt bed.

Paleolithic artifacts were found in four out of five trenches in Terrace 1 (Armand did not dig to the gravel level in Trench 7 because he hit the water table at 4 m. depth). As noted, the artifact-bearing gravels were sealed, hence most of them were undisturbed by colluvial erosion (Fig. VII 6).

Armand's purpose was to find the relationships among these artifact assemblages horizontally. Trench 6 was extended 4.5 meters to the north and west, exposing a 6x6 square meter area of the gravel surface that shows the distribution of artifacts on the occupation floor (Fig. VII 7). This horizontal excavation confirmed the stratigraphic evidence from the trenches.

Dating

Sankalia visited the excavation in February, 1971. He commented that "...at this place at least, the coarse pebble gravel is uncontaminated and since it contains only pebble tools and also rests on and against the basal rock, it is probably the earliest Pleistocene deposit" (Sankalia, 1971:18). This comment may be the best information that we can get for the dating of the site thus far. This is

because no fossil fauna have been found at Durkadi. However, *Bos namadicus* and *Elephas antiquus* were found in the similar coarse pebble gravel deposit of the Narsinghpur and Hoshangabad area of the central Narmada River (Supekar, 1968). This collateral evidence can be used only for reference in deciding the date of the gravel layer as belonging broadly to the Middle Pleistocene.

G.L. Badam tried to build a relative stratigraphic time scale for the Stone Age cultures of the Central Narmada valley on the basis of fauna. He suggests that the Red clay/Boulder Conglomerate horizon (Gravel I) that yielded Early and Middle Paleolithic tools along with typical Middle Pleistocene fauna may be between 40,000 and 150,000 B.P. (late Middle Pleistocene to early Upper Pleistocene) (Murthy, 1977). I would like to add a further point here. A partial skull was discovered in the Narmada Valley, near Hathnora, Madyha Pradesh, Central India in 1982. The human fossil was associated with Acheulian handaxes, cleavers, flakes, and choppers. It was originally identified as *H. erectus*. However, a more recent examination by K.A.R. Kennedy suggests that the Narmada fossil should be considered as an archaic *sapiens*. Kennedy assigns this fossil a late Middle or early Upper Pleistocene age, around 100,000 years ago (Kennedy, 1990). If these hominids lived in the Narmada Valley at that time, they would have manufactured artifacts and exploited the area for food.

This discovery makes the stratigraphic dating of Armand's terraces more reasonable, because there is now proof of hominid occupation corresponding to the dates Armand assigns to the terraces that contained the stone tools.

In Armand's conclusion, he emphasizes that Pleistocene evolution in Durkadi is made up of three climatic cycles: the plateau was formed during the first inter-pluvial (Lower Pleistocene); Terrace 1 was formed during the 2nd pluvial and 2nd inter-pluvial (Middle Pleistocene); Terrace 2 was formed during the 3rd inter-pluvial and 3rd pluvial; and Terrace 3 formed during the 4th pluvial. The last two terraces are Upper Pleistocene. The gravel level was probably deposited during a pluvial stage, when much of peninsular India was flooded. Corresponding to this period is the glacial stage in the Himalayas, which should be regarded as the second Glacial Stage (Mindel) there equal to the 2nd pluvial stage in peninsular India.

There were 650 pieces of lithic material collected in Durkadi during the 1970-71 field work. Approximately 16% of them were from excavation, the rest were collected from the exposed gravel surface. Analysis of both the surface and excavated material are reported in Armand's book because Armand thinks "the original stratigraphic position of the lithic material found on the surface was determined beyond any doubt on the basis of many trenches and natural sections" (Armand, 1983:79). Once Armand sets this

connection between the surface finds and the excavated finds he does not provide any further information as to the number of fresh and rolled artifacts coming from either source. He treats all the artifacts as one data set. There were 363 fresh pebble artifacts found in the top 35 cm. of the coarse pebble gravel of Terrace 1. Armand uses the term "Abbevillian", which has traditionally denoted the earliest handaxe industries, to denote the basic technologies of these specimens. The fresh pebble artifact assemblage is composed mainly of choppers and scrapers (22.87%, 83 specimens), with less than 2% proto-handaxes (6 specimens), just 0.28% (1 specimen) handaxes, and no cleavers (Armand, 1983).

There were also 287 rolled artifacts in the levels of the coarse pebble conglomerate of Terrace 1. The difference between the tool-type composition of the rolled artifact assemblage and the fresh artifact assemblage is that the rolled assemblage is devoid of proto-cleavers, proto-handaxes, and handaxes. Therefore, Armand divided the Durkadi industry into two different stages: Durkadian (Rolled Group) and the Developed Durkadian (Fresh Group). He then assigned the Developed Durkadian (with the emergence of handaxes) to the Middle Pleistocene period.

2. Description and Classification

Previous work

The first exploration of the Lower Paleolithic in the Narmada Valley of central India was by Teilhard de Chardin and De Terra and Patterson during the 1930s (De Terra et al. 1939). They suggested that the Narmada Valley should be a contact region of the two stone tool-making traditions: one is the "Chopper-chopping tool tradition", which is related to the Choukoudienian of China and the Anyathian of Burma and northern India. The other is the "Handaxe-cleaver tradition", which is related to the Madrasian of southern India and originated in Africa. These two stone tool traditions were thought to have arrived at roughly the same time in the Narmada Valley. This formulation influenced several generations of prehistorians in India. Many scholars worked in this area: Khatri (1956); Sankalia, Deo, Subbarao and Trivedi (1957); Joshi (1958); Sankalia and Subbarao (1958); Sankalia, Deo, Ansari, Subbarao, Malik, Mehta and Trivedi (1958); Sankalia, Subbarao and Deo (1958); and Supekar (1968). Their work consisted of the study of lithic artifacts but usually without stratigraphic evidence. Armand was the first to work with a primary site in this area, where one could define the stratigraphy and typological components of at least one Paleolithic industry.

Previous to Armand's book in 1983, he also published two articles about the Durkadi site (Armand 1974, 1979).

Both articles described the excavations of 1970-71. Other than his own work, few other publications refer to the Durkadi site. Sankalia was Armand's dissertation advisor, visited the excavation site, and affirms Armand's conclusions.

Another document that is relevant here is a review in the Bulletin of the Deccan College Postgraduate & Research Institute by Sheila Mishra (Mishra, 1986). Mishra thinks that the value of the publication lies in Armand's meticulous and complete description of the typological affinities of the industry. But she goes to great lengths to criticize Armand's description of the formation of the terrace. She suggests that the 99% quartzite that Armand uses to support his contention that the gravel is alluvial rather than colluvial is actually the result of the non-survival of the basalt and the re-deposition of the gravel in the Terminal Pleistocene. This means that the terrace was formed by a re-working of the deposit rather than being an original deposit. The large size quartzite is locally derived material, whereas, as Armand suggests, the finer pebbles may be transported a greater distance and be derived from Onkareswar 45 km. upstream of Durkadi. S. Mishra also believes that Armand should avoid using the terms "pre-Abbevillian" and "pre-Acheulian", because the typical types in these periods (handaxes, cleavers, polyhedrons, and spheroids) are absent in the Durkadi site (Mishra, 1986).

The method used for the classification of the lithic material is based on an analysis of the attributes of every single artifact. Under the two headings of Fresh Group and Rolled Group, he classified the artifacts into Cores, Unworked Flakes, Waste, Debitage, and Tools. There are Heavy duty tools (weighing more than 400 gm.), and Light duty tools as sub-divisions of the Tools class. The Heavy duty tools are basically choppers, and the Light duty tools are scrapers and borers. These stone tools are made from fine-grained quartzite pebbles. This material is plentiful along the present Narmada River. Armand's description of the overall appearance of the Durkadi lithic industry says that the tools retain large areas of the cortex and have no standardized forms; the retouching is limited to the working edges; the flake scars are uneven and commonly alternate on both lateral edges. This industry is "basically a pebble industry of crude scrapers and choppers, with an incipient tendency towards less archaic tool-types such as proto-handaxes, proto-cleavers, pebble-butted handaxes and crude burins and borers" (Armand, 1983:91).

The Collection

Armand's collection from Durkadi Nala in 1970-71 is stored at Deccan College, Poona, India. A few artifacts have been lost, and three of the other tools (a handaxe, a proto-handaxe and a side-chopper, which are Armand's

evidence proving the three grades of the handaxe evolution in Durkadi Nala) are being exhibited in the Museo Arqueologico of the Universidad de los Andes, Merida, Venezuela. As already noted, there were also some stone artifacts on exhibit in the Museum of Deccan college that were unavailable for study at the time I was in Poona. The rest of the collection is in 4 large boxes in a back room of the college's museum (Fig. VII 8). The artifact collections are piled together inside these boxes, and the artifact serial number is marked on each artifact (there is no catalog available to tie serial numbers to the proveniences of these artifacts). I went through each box, and selected examples that were more or less different in shape, type, and technique. The original Fresh Group and Rolled Group categories are mixed together in the storage boxes, but by inspection I chose some specimens from each group. I recorded 24 specimens in the study (Table 7).

Core with single unifacial edge [C1] (1 specimen)

Specimen 00818 is made on a flat, quartzite cobble, which is in fresh condition. Approximately half of the circumference has been trimmed unifacially along the length of the cobble. The edge is nearly straight, with three deep negative scars. The lower face and other half of the upper face consists of cortex surface. The single edge is jagged.

The length/breadth/thickness measurements are 110x78x48 mm., the weight is 600 gm. (Fig. VII 9).

Core with unifacial distal end perpendicular to both edges [C3] (1 specimen)

Specimen 00596 is made on a split quartzite cobble with cortex surface retained on one face, which is in fresh condition. The shape of the specimen is almost rectangular in both vertical view and profile view. The lower face is flat with a natural cracked surface. The proximal end is quite straight. Both lateral edges and partial distal edge are trimmed unifacially from the lower face to the upper. The flake scars vary in size, and some of them are deeper than others. The edges are jagged from damage. The length/breadth/thickness measurements are 108x128x54 mm., the weight is 1,700 gm. (Fig. VII 9).

Core with unifacial edges in other shapes [C8] (1 specimen)

Specimen 00586 is made on a flat quartzite cobble, which is in fresh condition. The shape of the specimen seems to be square. This is because one lateral edge and the distal edge were formed by a single vertical trimming scar struck from the lower face to the upper. The proximal end is also straight. There is a shallow flake scar on the other lateral edge, also trimmed from lower face to upper. The rest of the surface still retains cortex. There is edge

damage present on all the edges. The length/breadth/thickness measurements are 117x124x88 mm., the weight is 1,300 gm. (Fig. VII 10).

Core with single bifacial edge [C9] (4 specimens)

Four specimens are made on flat quartzite cobbles, which are in fresh condition. All of them have some cortex surface at one end, but this is located on different sides: the cortex ends of specimens 00530, 00001, and 1971A are along the lengths of the cobbles, the transverse working edges were trimmed approximately half of the circumference of the tools; the cortex surface of specimen 00047 is on the butt, approximately one third of the circumference having been trimmed on the transverse end. The entire single edge is trimmed bifacially, but there are multiple flaking scars on one face each of the specimens 00530 and 1971 A, opposed to a single scar on the obverse. The length/breadth/thickness measurements of 00530 are 149x102x64 mm., of 1971 A are 172x117x60 mm., and the weight of 00530 is 1,200 gm. (Fig. VII 10), of 1971 A is 1,400 gm. (Fig. VII 12).

Specimens 00001 and 00047 are bifacial, with multiple flaking scars on both faces of a single edge. The edge is steeply trimmed. The length/breadth/thickness measurements of 00001 are 214x134x80 mm.; of 00047 they are 88x86x28 mm.

The weight of 00001 is 3,000 gm. (Fig. VII 11), of 00047 is 300 gm. (Fig. VII 12).

<u>Core with one bifacial leaf-shaped end [C13] (1 specimen)</u>

Specimen 00571 is made on a comparatively thicker, flat quartzite cobble, which is rolled. It is flaked over both faces, the lower face is covered entirely with flake scars, and there is some cortex surface on the central portion of the upper face. The butt is sub-rounded, and the tip bluntly pointed. The edge is uneven and extends around almost 95% of the circumference. Because the edge is rolled it is difficult to determine whether this tool exhibits edge damage. The length/breadth/thickness measurements are 128x95x56 cm., the weight is 900 gm. (Fig. VII 13).

<u>Core with two bifacial leaf-shaped ends [C14] (1 specimen)</u>

Specimen 00593 is made on a thick, lozenge shaped quartzite cobble. Bifacial flaking extends around a great part of the circumference, and both faces retain a small portion of the cortex. The tip is sharp, and one side of the butt is formed by an oblique, vertical fracture plane. It is also in fresh condition. The flake scars are uneven. Edge damage is present on both points. The length/breadth/thickness measurements are 132x98x66 mm., the weight is 1,100 gm. (Fig. VII 13).

Core tool in other shapes [C17] (3 specimens)

Three specimens are made on quartzite cobbles and are irregularly shaped; all are in fresh condition. They are characterized by having a minimum of three edges that have edge damage, and each has been blunted and battered on all the projecting parts. The surfaces have necessarily been much more extensively flaked than usual. Specimen 00187 is nearly square, without any retaining cortex. There is a straight negative flake scar which was used as a platform on one face, to trim off a series of flakes. The other face was trimmed from several different directions. The edges, which are retouched bifacially, are jagged. The length/breadth/thickness measurements are 99x114x58 mm., the weight is 1,100 gm. (Fig. VII 14).

Specimen 00373 is formed on a stone that was roughly subspheroid. The surface retains part of the rounded cortex in the central area. The flaking extends around the partial circumference, and the flake scars are shallow and consistent. The length/breadth/thickness measurements are 86x77x56 mm., the weight is 500 gm. (Fig. VII 15).

Specimen 00559 is a large, square tool. One end is formed by an oblique vertical fracture plane that is very thick. The transverse edge is sharp and jagged. The profile of the tool is like that of a chisel. There is only a small portion of the cortex left. The

length/breadth/thickness measurements are 160x138x119 mm., the weight is 2,400 gm. (Fig. VII 14).

Flake with single lateral unifacial edge [F1] (3 specimens)

All three specimens are made on thin quartzite flakes, which are in fresh condition. There are steep flake scars along only one edge; that edge is sharp, and jagged from damage. The flaking is on one face, and the edge is straight or convex. The bulb of percussion is marked. Specimen 00329 is made on a complete flake that has been taken off the side of a cobble. Hence, the striking platform and distal end are both thinner than the central part. There is cortex covering the entire dorsal face. The single working edge extends from proximal to distal, and was flaked from the dorsal face to the ventral. The length/breadth/thickness measurements are 96x68x25 mm., the thickness and breadth of the platform are 5x61 mm., the angle of the platform is 95 degrees, and the weight is 300 gm. (Fig. VII 15).

Specimen 00354 is also made on a complete flake, but the striking platform is a negative flaking scar. Hence, the thickest portion of the flake is on the platform, and the distal end retains the natural sharp shape. There is cortex on the dorsal surface. The single lateral edge is flaked from the ventral face to the dorsal. There is edge damage present on the lateral edge and the distal end. The

length/breadth/thickness measurements are 70x93x27 mm., the thickness and breadth of the platform are 27x39 mm., the angle of the platform is 129 degrees, and the weight is 90 gm. (Fig. VII 16).

The dorsal face of specimen 00352 is a natural fracture surface. The striking platform and the distal end are straight and parallel to each other, with almost equal thickness. One lateral edge retains cortex on the surface, which is oblique. The other lateral edge is made from ventral face to dorsal and is jagged. There is edge damage present on the distal end. The length/breadth/thickness measurements are 92x90x26 mm., the thickness and breadth of the platform are 26x53 mm., the angle of the platform is 129 degrees, and the weight is 100 gm. (Fig. VII 15).

Flake with unifacial distal end perpendicular to double lateral edges [F3] (1 specimen)

Specimen 00221 is made on a complete quartzite flake, which is in fresh condition. The striking platform is straight with a broad flake scar, the bulb of percussion is well marked. The width of the flake is almost two times its length. There is a ridge along the central axis of the flake on the dorsal face. About half the distal end still retains cortex surface, the other half of the distal end is trimmed from ventral face to dorsal. Both lateral edges are trimmed unifacially, but in opposite directions (alternate).

There is edge damage present on both lateral edges, and on the distal edge. The length/breadth/thickness measurements are 66x112x31 mm., the thickness and breadth of the platform are 31x59 mm., the angle of the platform is 93 degrees, and the weight is 300 gm. (Fig. VII 16).

Flake with unifacial leaf-shaped distal end [F5] (2 specimen)

Two specimens are made on thick quartzite flake, knapped into a symmetrical oblong shape. No cortex remains on the surface of either specimen. The dorsal faces are intensively trimmed around the entire circumference from ventral face to dorsal, forming a median point at the distal end. The bulbs of percussion are well marked. The edges of both specimens are jagged from damage.

There are several large and shallow flake scars on the central area of specimen 00361, and steep trimming scars around the edges. There are two flake scars on the platform. This specimen is in fresh condition. The length/breadth/thickness measurements are 107x88x39 mm., the thickness and breadth of the platform are 21x60 mm., the angle of the platform is 120 degrees, and the weight is 500 gm. (Fig. VII 16).

Specimen 00555 is rolled. Large and shallow flake scars form a ridge along the length of the flake at the intersection of the dorsal face. Because the back of the

platform is also trimmed, both proximal and distal ends are much thinner than the central portion. The length/breadth/thickness measurements are 170x112x60 mm., the thickness and breadth of the platform are 40x75 mm., the angle of the platform is 135 degrees, and the weight is 1,100 gm. (Fig. VII 17).

<u>Flake with bifacial distal end perpendicular to double lateral edges [F14] (1 specimen)</u>

Specimen 00056 is made on a broad, nearly square quartzite flake, which is in fresh condition. The striking platform is formed by two flaking scars, and is vertical to the length of the tool. The bulb of percussion is not well marked. Large, steep flake scars were trimmed bifacially around both the lateral edges and the distal end. Cortex remains on a small portion of the dorsal surface. Three working edges are sharp, and they are also jagged from damage. The length/breadth/thickness measurements are 133x124x50 mm., the thickness and breadth of the platform are 21x74 mm., the angle of the platform is 90 degrees, and the weight is 1,300 gm. (Fig. VII 17).

<u>Flake with bifacial proximal end [F19] (1 specimen)</u>

Specimen 00358 is made on a small, thin quartzite flake, which is in fresh condition. The proximal extremity is more pointed than the opposite end, which is relatively

thin and broadly spatulate. The bulb has been trimmed away, hence the angle of the platform and the thickness and breadth of the platform are not available. There are trimming scars covering the dorsal face and only a small portion of the cortex remains along one lateral surface. There is also a portion of untrimmed natural fracture along the same lateral edge on the ventral face. There is edge damage present along the entire edge, which is jagged. The length/breadth/thickness measurements are 90x68x30 mm., and the weight is 200 gm. (Fig. VII 18).

Unmodified flake [U1] (4 specimens)

Four specimens are complete quartzite flakes, which are in fresh condition. The bulb of percussion is generally pronounced. Although they are not trimmed, the edges are usually jagged by damage. The edge damage is present on different locations on each specimen. Specimen 00179 is a small flake, and the distal point was damaged. Two previous flake scars form a ridge along the central length of the flake. Hence, there is no cortex on the dorsal surface. The striking platform is the thickest portion of the flake. There is edge damage present on both lateral edges. The length/breadth/thickness measurements are 64x46x23 mm., the thickness and breadth of the platform are 23x30 mm., the angle of the platform is 135 degrees, and the weight is 100 gm. (Fig. VII 18).

Specimen 00727 is a flake whose width is greater than its length. The primary ventral surface is markedly convex at the bulbar end, with the bulb extending the whole length of the flake. The striking point was cracked when the flake was taken off the original cobble. The cortex remains on the rest of the dorsal face. The entire sharp natural edge is sawtoothed by damage. The length/breadth/thickness measurements are 68x84x26 mm., the thickness and breadth of the platform are 5x52 mm., the angle of the platform is 95 degrees, and the weight is 400 gm. (Fig. VII 18).

Specimen 00707 is a nearly rectangular flake. The platform is a flat vertical surface, which is oblique to the length of the flake and transverse to one lateral edge of the flake. There are previous flaking scars on the other lateral edge and on a portion of the dorsal face. Cortex covers the rest of the dorsal face. The distal edge was heavily damage, it is jagged and blunted. The length/breadth/thickness measurements are 131x110x44 mm., the thickness and breadth of the platform are 35x84 mm., the angle of the platform is 125 degrees, and the weight is 1,000 gm. (Fig. VII 19).

Specimen 1971 was taken off the side of an oblong cobble, hence, the proximal and the distal ends are equally sharp, and much thinner than the central portion of the flake. Cortex remains on the entire dorsal face. Both the lateral edges and distal edge are blunt from damage. The

length/breadth/thickness measurements are 148x112x46 mm., the thickness and breadth of the platform are 10x53 mm., the angle of the platform is 95 degrees, and the weight is 1,100 gm. (Fig. VII 19).

3. Analysis and Replication

Technology

The raw material that was selected to make these stone tools consists of quartzite cobbles. Twenty specimens (83%) retain cortex, ranging from 10 to 67 percent, with an average of 38 per cent. There are four specimens (17%) with no cortex surface; this includes 3 flake specimens (00555, 00361, and 00179) and 1 core specimen (00187).

There are 12 core specimens in the collection (50%). This percent is similar to the proportion between core and flake specimens in Armand's excavation report. There are 75 specimens illustrated by drawings or photographs. Of these, 39 are core specimens (52%), and 36 are flake specimens (48%). There are also 56 specimens described individually in the excavation report. This includes 22 cores (42%), 31 flakes (58%), and 3 pieces of waste material. The total of 131 illustrated specimens represents 29 artifact-types (classified by Armand), and is about 20% of all the artifacts found in Durkadi.

The length/breadth/thickness measurements of the core tools range from 214x134x80 mm. to 86x77x56 mm., with an

average of 130x108x65 cm. There are 9 (75%) cores in which the length is greater than the breadth, 3 (25%) for which the breadth is greater than the length. The weights of the cores range from 3,000 gm. to 300 gm., with an average of 1,291 gm. The number of flake scars on the core specimens ranges from 16 to 3, with an average of 8. This number indicates that the flintknappers fully used each piece of raw material to produce flakes or to sharpen the edges. The edges of 4 (33%) cores were made unifacially, and 8 (67%) were made bifacially.

There are 12 flake specimens. The length/breadth/thickness measurements of the flakes range from 170x112x60 mm. to 64x46x23 mm., with an average of 103x92x36 mm. There are 9 (75%) flakes with lengths greater than breadths, 3 (25%) for which the breadth is greater than the length. There is only 1 specimen 00358 that does not retain its platform (it has been trimmed away). Platform thickness on the other flakes ranges from 35 mm. to 5 mm., with an average of 22 mm. There are 3 flake tools whose platforms are the thickest portions of the flakes. Platform breadths range from 84 mm. to 30 mm., with an average of 64 mm. The ratio of thickness to breadth of the platforms is 1:2.1. There are 3 (25%) specimens (see 00329, 00352 and 1971) that retain cortex on the platform. There are 3 specimens (see 00707, 00361 and 00056) that have 2 flake scars on the platform where previous flaking had taken

place, and so do not retain evidence concerning platform preparation. The platform of specimen 00727 was cracked in the striking process, leaving crack scars on both dorsal and ventral faces. On specimens 00354, 00221, 00555, and 00179, flat negative flake scars were used as the platforms, and hence there are no retouching scars on these platforms.

Platform angles range from 135 to 90 degrees, with an average of 113 degrees. These 11 flake specimens can be divided into two groups: the angles of 6 specimens (55%) are around 130 degrees (00179:135; 00707:125; 00361:120; 00555:135; 00352:129; and 00354:129), and 5 specimens approximate 90 degrees (00727:95; 1971:95; 00329:95; 00056:90; and 00221:93). There is no obvious relationship between platform angle and platform shape. For example, the platforms of specimens 00352 and 1971 both retain cortex, but the platform angles are very different (one is 129 degrees, the other one is 95 degrees). Another example is provided by specimens 00707, 00361, and 00056: all three have 2 flake scars on the platform surfaces, but the angles of the platforms are different: 125, 120, and 90 degrees.

There are 4 (33%) specimens that are <u>Unmodified flake</u>. These have no retouch scars on their edges. As for the rest of the 8 specimens, 2 (25%) of them are made bifacially, 6 (75%) of them are made unifacially. Specimen 00329 is flaked from dorsal face to ventral. Four specimens (00361, 00555, 00352, and 00354) are flaked from ventral face to

dorsal. The lateral edges of specimen 00221 are made from opposite directions, one is from ventral face to dorsal, the other is from dorsal face to ventral.

As noted, fresh artifacts are present only in the top 35 cm. of the sealed coarse pebble conglomerate of Terrace 1, while rolled artifacts occur in all the levels of this conglomerate. There are no proto-handaxes or handaxes in the Rolled Group. On the basis of these differences in stratigraphy, state of preservation, and tool-type, Armand divided the Durkadi industry into two different stages: the Durkadi (Rolled Group) and developed Durkadi (Fresh Group). Most important here is Armand's hypothesis concerning the three grades of handaxe evolution in Durkadi Nala: first, Bifacial side-chopper (most limited in Rolled Group); second, Proto-handaxe; and third, Handaxe (most limited in Fresh Group).

In order to distinguish Armand's two periods in my sample, I have carefully noted in the description of every specimen whether it is in fresh condition or rolled condition. There are only 2 specimens in this study that are rolled: one is 00571 [C13] <u>Core with one bifacial leaf-shaped end</u>, and the other is 00555 [F5] <u>Flake with unifacial leaf-shaped distal end</u>. The core tool (00571), in fact, is trimmed bifacially for 95 percent of the circumference; the butt is sub-rounded, and the tip is leaf-shaped, the cortex remains only on the central portion of the dorsal face.

This specimen is quite similar to two specimens illustrated by Armand: specimen 582, which he calls an early Abbevillian type of Handaxe; and 343, termed an evolved proto-handaxe, both of which Armand states are present only in the Fresh grouping. I could not examine the direct evidence because Armand's 3 typical examples of handaxe evolution are in Venezuela. I must rely on his illustrations to make my case. Certainly the example above, the core tool 00571, which comes from the rolled group, is strikingly similar to Armand's early Abbevillian type of handaxe. But one example is not enough to throw significant doubt on Armand's belief that the rolled group consists of side-choppers only. There are 22 fresh specimens, and only 2 rolled specimens in my study because the rolled specimens in Armand's collection stored at Deccan College are basically side-choppers as Armand classified them. Many are too rolled to show any trimming scars or use marks so it would be difficult to use them in a study. Faced with these limitations, I find it difficult to come to any conclusion.

The bifacial technique is employed mostly on the core tools (67% of core specimens), and on only 25 per cent on the flake tools in my study. This proportion is similar in the 131 artifacts illustrated in the original excavation report. Of 61 core specimens, 40 (66%) are made bifacially, 17 (28%) are made unifacially, and 4 are unretouched. Of the 70 flake specimens, 17 (24%) are made bifacially, 39

(56%) are made unifacially, and 14 (20%) are unretouched. Unfortunately, this number includes items from both the fresh tools group and the rolled tools group. If the original records noted which tools were from the Fresh Group and which were from the Rolled Group, it would be easier to see the development and changes in stone tool industry between these two groups. Given a large proportion of bifacial core tools, the problem is not so much building an evolutionary sequence as Armand has done, but rather explaining why there was a technological evolution within the 1.3 meter thick, coarse pebble gravel deposit. The reasons for this technological evolution in one area (if indeed there was one) is Armand's real challenge. Did the technological evolution take place on this site as Armand would have us believe, or are the Rolled artifacts in a horizontal level to be recognized as important warnings of the strong influence of fluvial or other sedimentary processes in the site's history? In fact, the kind of pronounced rolling seen in the Rolled Group of the collection, which appears on all the surfaces of the tool and not only as edge damage, could also have been caused by chemical weathering, or caused by ground water.

Selection of Lithic Raw Material

I stayed at a Guest House next to the ancient fortress of the Holkar Maharajas. The fortress faces south, its huge

gate and steps leading down to the green Narmada river. Because the Durkadi Nala is located on the other side of the river, I had to hire a ferry to carry all the equipment across (Fig. VII 20).

As soon as the ferry stopped at the first Nala at dawn, it was easy to see the various sizes of the cobbles that covered the south bank of the river (Fig. VII 20). I walked along to the Durkadi Nala, where there were cobbles up to 10 km. south of the river. These numerous, well rounded quartzite cobbles would certainly have been an easy local source for Durkadians to use in making stone tools. According to Armand, there should be three fluvial terraces here that can be distinguished as one looks towards the south. As I walked around the area, however, I could not see distinctive terrace levels. There were many east-west running dikes, so that one must climb up and down constantly. This is because the Narmada river floods seasonally, often overflowing its banks and causing heavy damage to crops, property, and animal life. There are no fields or houses near the river banks; this area is a waste-land. The vegetation is sparse, mainly grass, shrubs, and a few trees. The excavation area looked as though it was mostly covered by later disturbances (Fig. VII 21).

The water purifier broke on the way to Durkadi. I finished the last 9 bottles of soda at Maheshwar village, which was where I was staying. I was out of drinking water,

and, at the same time, suffered from diarrhea. Under these conditions the replication work was very difficult. Quartzite cobbles are the only raw material available, and they are very hard. I used stone hammer direct percussion, with my left hand supporting the cobble (I was unable to find a large rock to sit upon). The striking platform was on the surface of the cobble. The best I could do was to remove thick flakes and big chunks from the cobble. Replacating tools can be divided according to the location of their retouch into unifacial or bifacial. When I worked with the quartzite cobbles on the Narmada river bank, I could feel that the smoothness, fine-textured, and hardness of the cobbles were very similar to those attributes of cobbles from the Han River, the Ba River, and the You River of China. Direct percussion is the only technique I can suggest for use on this kind of raw material. Because I could not work there long without drinking water, I was unable to carry out my replication program at the site, but I did take several cobbles with me for the geological thin section of the lithic raw material (see Appendix A) (Fig. VII 21). When I left Durkadi, I intended to return to the site later. However, I was unable to extend my visa so had to leave India without completing my research at Durkadi.

The Durkadi research presents a paradox. On the one hand, I appreciate the detailed methodical approach that Armand uses in the excavation and stone tool analysis. On

the other hand, I do not believe Armand's claim that there is a technological evolution between the fresh and the rolled tool groups. I doubt Armand's division here for several reasons. First is the stratigraphic situation of the two layers, which are superimposed with no separating layer. There is no reason to see these groups as belonging to two different, discontinuous time periods, and the total deposit is only 1.3 meters thick. Yet Armand claims that the technological evolution took place within these deposits; therefore, within a relatively short period of time.

The second reason that casts doubt on Armand's claim is the condition of the rolled tools. Armand's contention that there are no handaxes in the rolled group can be questioned. In my study I did find a rolled specimen that was a proto-Abbevillian handaxe according to Armand's terms. Moreover, it is difficult to identify the characteristics of the rolled specimens, so it is impossible to know whether others may have been rolled beyond recognition.

The last questionable aspect of Armand's evidence is the technological division. In both Armand's study and mine, the majority of the tools were found to be bifacial in both the fresh and rolled groups. There are two problems with this. First, from the content of type and technology (basically bifacial), there is not much difference between the fresh group and the rolled group. The second point is

that if they can produce one bifacially trimmed edge, it is beyond doubt that they could produce two or three bifacially trimmed edges. It would depend on the flintknappers what kind of material was used, where the retouching was placed, and what forms or shapes of tools they intended to make. If the bifacial technology was there in the early period and it is throughout the entire deposits then why do they need a technological evolution to make handaxes? The answer is that a bifacial side chopper was sufficient for the life needs of the tool producers. If I ever have a chance to return to Durkadi Nala, I will replicate the stone tool assemblage to demonstrate that bifacial techniques can be employed on different edges or sides of the cobbles. This would also bring out the connection between the shape of the raw material and the typology of the tools made from it.

Chapter 9 Hunsgi

This collection of sites represents the Lower Palaeolithic occupation of the Hunsgi valley system of Shorapur Taluk (in the Gulbarga District, Karnataka State, India). K. Paddayya of Deccan College worked for six years investigating over 100 Acheulian localities within a radius of ten kilometers around Hunsgi (Fig. VIII 1). He has studied the archaeological records and specific sedimentary context of a number of these sites.

The first site was discovered in 1969, at a two meter thick fluviatile deposit in the Gulbal (southwestern corner of the Hunsgi valley, now Gulbal Locality II). There are handaxes, cleavers, and other artifacts made of limestone, which suggest that an Acheulian phase also can be expected in the Hunsgi valley. In 1974, the Public Works Department exposed some limestone artifacts in earth dug from the right bank of the Hunsgi stream at the Hunsgi valley. Paddayya excavated a trench (6.5 m.x 4 m. in area, 1 meter deep) in order to ascertain the stratigraphic context of these artifacts (now Hunsgi Locality III). He found 500 artifacts in fresh physical condition with large angular blocks of granite in the sediment leading him to believe that the artifact assemblage was in the primary context.

During the years 1975-77, a number of excavations were conducted along a one-kilometer stretch of the Hunsgi

stream. Two of these systematic excavations are very important to this study: Locality V and Location VI, both of which exposed the Acheulian occupation floors. The floor yielded a total of 918 artifacts at Locality V, and 930 artifacts from the lower occupation horizons at Locality VI. Paddayya took pollen samples at Hunsgi Locality V. In the two seasons of 1978-79 and 1979-80, about 40 small and large Acheulian occurrences were discovered in intensive surveys covering the valley floor as well as the tablelands encircling the valley. Paddayya's main conclusion is that "this fresh evidence fully supports the suspected phenomenon of seasonality in the settlement and subsistence behavior of the Acheulian groups" (Paddayya 1982:5).

There were about 10 pieces of fossil bone from five different occupation sites on the valley floor (Paddayya, 1985). Nevertheless, the Acheulian horizon has been continually disturbed by ploughing and related agricultural activities, exposing paleontological and cultural material on the surface. Despite the fact that these items are being recovered from the surface, Paddayya believes that the fossilized bone comes from the Acheulian horizon.

While there are many sites in the Hunsgi valley that have been identified as belonging to the Acheulian culture, I focus on only one site here, Locality V. I also refer to three specimene from Locality VI. The reason that I chose these sites is that they were excavated from a sealed

horizon and the excavations have been published (Paddayya, 1977).

1.Geological and Archaeological Background

Location

The Hunsgi valley is an oval-shaped basin covering an area of about 480 sq. km. (15 km. north-south and 10 km. east-west) (Fig. VIII 2). The valley lies about 450 m. above sea level and is enclosed by shale and limestone plateau rising to a height of 70 m. from the valley floor (Fig. VIII 3). The major geological formations of the area are granite, shales, limestones, and Deccan Trap (Mahadevan, 1941). Granite is distributed on the southeastern part. Deccan Trap is found in the northwestern and southeastern corners. The largest area, formed by shales and limestones, is called the Bhima Series, and occupies the tablelands as well as a main portion of the valley floor. There are several springs at contacts between these varied geological formations, which provide a dependable source of drinking water for the area. These spring waters converge into several minor streams that cut across the valley in an easterly direction (Fig. VIII 4). The valley floor slopes down gently from west to east. These streams join above the village of Hunsgi, forming a bigger stream, the Hunsgi Nullah (Fig. VIII 4). While there is some variation, the present nullah generally has a breadth of 35 meters, and 2

to 3 meter high banks. The ancestral stream of this Hunsgi Nullah flowed at a higher level (2 to 3 m. above the present bed) and in a much broader channel system (about 200 m. across) (Paddayya, 1982). The Hunsgi Nullah joins the Krishna River after an easterly course of about 35 km.

Locality V lies at about 16.27 degrees north latitude, 76.31 degrees east longitude. It is on the left bank of the Hunsgi Nullah and lies half a kilometer northeast of the village. The area of the site is in a horeseshoe shape of about 10,000 square meters. There are two small branches of the Hunsgi Nullah on the eastern and northeastern boundary and a field on the west side. Granite boulders of various sizes dot the site, somewhat concentrated on the borders between the site and the Hunsgi stream, as well as the site and the two branches of the Hunsgi stream (Fig. VIII 5).

The most useful results for Locality V came from Trench 3, which lies 45 m. from the bank of the Hunsgi stream and 4 m. above its bed. This is the trench closest to the Hunsgi stream. The total excavated area was 22.75 square meters (Fig. VIII 6). Paddayya states that the "excavation revealed a primary cultural level measuring about 9 m. in length (east-west), with its eastern and western limits marked by natural clusters of granite blocks forming part of the bedrock" (Paddayya, 1977:346). This phenomenon implies an Acheulian occupation that took place on a boulder-strewn rock surface. The Acheulian floor is made up of sub-angular

to sub-rounded pebbles and cobbles of limestone, which might have been obtained from the limestone plateau region lying only 2 to 3 km north. There was also a little sandstone, quartzite, dolerite, shale, and chert in the composition of the floor (Fig. VIII 7).

Locality VI is similar to Hungsi V. Locality VI is northeast of Locality V, and also on the left bank of the Hunsgi stream (Fig. VIII 8). The excavation area of Trench 1 at Locality VI measures 8x6 square meters. The occupation deposits are fairly thick here (1 meter). As at Locality V, the Acheulian occupation floors were exposed with large granite boulders.

Stratigraphy

There are two stratigraphic sections that could serve as examples: one is the section recorded in Trench 3 of Locality V (Paddayya, 1977), the other is the section recorded in Trench 1 of Locality VI (Paddayya 1982). The deposits of the Trench 3 section are over 1.4 meters thick and are divided into 4 layers from top to bottom (Fig. VIII 9):

1. Black soil, maximum thickness is 0.3 m.

2. Loose, dark brown secondary gravel with scattered artifacts and sub-angular pebbles of limestone, maximum thickness is 0.7 m.

3. Acheulian floor, thickness is 0.2-0.35 m.

4. Bedrock (granite) partly weathered into gruss (in sedimentological literature this means a situation where the individual mineral grains are only loosely attached to one another, thereby rendering the whole rock mass disaggregated).

According to the original excavation report, the Acheulian floor is compact and extremely hard to dig, but the overlying secondary gravel is predominantly silty and sandy.

The deposits of the Trench I section at Hunsgi VI are about 1 meter thick, and are divided into 5 layers from top to bottom (Fig. VIII 10):

1. Loose greyish black soil very much disturbed, containing Mediaeval pottery, animal bones, and Mesolithic artifacts made of whitish chert, as well as flakes and chips of limestone. Thickness is 0.2 m.

2. Gruss mixed with greyish black soil, the cultural materials being the same as in the above layer, but there are far fewer of them. Thickness is 0.1 m.

3. Brownish and whitish gruss formed due to *in situ* weathering of granite, containing Acheulian tools and debitage of limestone (Acheulian horizon 1); pottery and Mesolithic artifacts rare. Thickness is 0.2 m.

4. Brownish and whitish gruss, hard, containing Acheulian artifacts (Acheulian horizon 2). Thickness is 0.25-0.3 m.

5. Sterile gruss mixed with granite blocks.

There are two Acheulian floors in this section, but the presence in the upper floor of a small quantity of pottery and Mesolithic artifacts indicates a partial disturbance. Many artifacts of the lower floor show a layer of carbonate encrustation, thereby implying that this floor was subjected to prolonged waterlogging.

Dating

During the 1981 to 1983 surveys, Paddayya found some 10 pieces (1 dental and 9 osteological remains) of fossil bones along with stone artifacts at some of the Acheulian localities, as well as 7 pieces (2 dental and the rest osteological remains) at six isolated spots on the valley floor (Fig. VIII 11). A.A. Kshirasagar of the Chemistry Laboratory of the Institute carried out chemical tests on these fossil bones. The result shows that their flourine/phosphate ratio ranged between 6.7 and 8.3, which is much higher than the value of 0.22, which was the result of the tests on a Neolithic site in the Hunsgi valley. Paddayya suggests that "these [results] reveal the contemporaneity of the fauna with the Acheulian culture, which on typo-technological grounds could be placed in the later part of Middle Pleistocene or else the early part of Upper Pleistocene" (Paddayya, 1985:).

There are half a dozen radiometric dates Uranium-series technique for the Acheulian culture of the Hunsgi-Baichbal valleys now available (Szabo, et. 1990). The two most relevant of these dates for this study come from the site of Kaldevanhalli in the Hunsgi valley (Fig. VIII 11). The Kaldevanhalli site is associated with travertine resulting from fossil spring activity. This sediment occupies an area of 1,000x200 square meters, and is 3 meters thick. There are 5 localities that lie 100 to 200 meters apart. Three travertine samples for dating were collected from one of the quarry sections. Two results are: a corrected age of 174,000 +/- 35,000 years, and an uncorrected age of 166,000 + 15,000/-13,000 years. These dates once again strengthened the earlier conclusion about the Acheulian culture of the Hunsgi valley as running from the late Middle Pleistocene to the early part of the Late Pleistocene.

The Acheulian site at Chirki on Pravara is thus far the only discovery of a Lower Paleolithic site that contains both animal remains and a rich stone tool assemblage in a primary context (Corvinus 1968). While dating sites from the lower limit of the Acheulian by the discovery of organic remains is not easy (Paddayya, 1985), the faunal and stratigraphic evidence from this site has been dated to 700,000 years ago, roughly the late Middle Pleistocene or early Upper Pleistocene (Rajaguru and Pappu, 1973). Paddayya, from a purely techno-typological point of view,

suggests that the Hunsgi industry resembles those from Chirki and, like some of the other Acheulian sites in Peninsular India, belongs to this period.

Paddayya's techno-typological criteria follow G. Isaac's work, which specifies a twofold division of the African Acheulian: Lower Acheulian characterized by simpler workmanship, and the Upper Acheulian characterized by refined forms and the employment of improved techniques of manufacture (Isaac, 1969). Using this general framework, Paddayya analyzes several characteristics of the Hunsgi stone tool assemblage and applies these features to the Lower Acheulian division. First, the majority of handaxes and cleavers are manufactured by the stone hammer technique; second, the work is usually found only along the tool margins and there are very few specimens with regular outlines or shallow retouch scars; third, the cross-section is usually irregular and thick; fourth, choppers, picks, polyhedrons and knives are found in fairly large number; fifth, the secondary working on the scrapers is rough and cannot be compared to the more refined scrapers of the Middle Paleolithic (Paddayya, 1977). Paddayya concludes that, as regards "the quality of secondary working and regularity of shape, these artifacts do not stand comparison with their counterparts in the succeeding Middle Paleolithic industry" (Paddayya, 1977: 353).

Although the cultural evidence exposed on the Acheulian floor at Locality V is limited to stone artifacts, other kinds of collateral evidence have been presented. These are the results of the chemical tests on the fossil bones from Hunsgi valley; the Uranium-series radiometric dates of the two travertine samples from the site of Kaldevanhalli in the Hunsgi; indirect dating from the Acheulian site at the Chirki; and techno-typological comparison to African Acheulian assemblages. This collection of evidence suggests that Hunsgi may date to the late Middle Pleistocene or early Upper Pleistocene. J. Desmond Clark of the University of California at Berkeley thinks that this hominid occupation in the Hunsgi valley "might be considered to have belonged to an advanced form of *Homo eretus* or to have been robust and early representatives of *Homo sapiens* (Clark, 1982: Foreward).

2. Description and Classification

Previous work

Most of the publications about the archaeological sites in Hunsgi valley have been written by K. Paddayya. In 1975 he published a preliminary report of the 1974 discoveries (Paddayya, 1975). This was the first time the Hunsgi sites were brought to public attention. In 1977, he published two summaries of the results of the 1975 - 1976 excavations at Locality V of Hunsgi. These articles provide details about

the Hunsgi area, the environmental setting of the site, the occupation floor at Locality V, and the lithic industry. An article titled "New Research Design and Field Techniques in the Paleolithic Archaeology of India" appeared in 1978, in which some problems concerning the Hunsgi Acheulian culture are described (Paddayya, 1978). In 1982, Paddayya published the final monograph of the Hunsgi valley Acheulian project, presenting a model of the hominids' relationship to their environment and to the various resources available to them. He reassesses studies of the Indian Paleolithic by making use of ecological evidence and drawing out the consequences of resource potential in a comparative model (Paddayya, 1982).

Acheulian occupation sites yielded fossil faunal remains in association with artifacts from the Hunsgi-Baichbal that came to light in the investigation from 1981 to 1983. G.L.Badam and K. Paddayya prepared a detailed study of the fossil faunal collections in the area (Paddayya, 1985). Kshirsagar and Paddayya used flourine analysis of bone samples to issue a relative chronology for the localities in Hunsgi (Kshirsagar, 1989). The significance of this study is that it corrected the traditional, rather pessimistic view, which stated that unfavourable soil conditions made it unlikely that organic remains would be found from the Stone Age in India (Kennedy, 1977). More than 6 ratiometric dates on the travertine

samples from the Hunsgi-Baichbal valley (obtained by the Uranium-series technique) were published in 1990 (Szabo et al., 1990). These dates once again affirm Middle to early Late Pleistocene age for the Acheulian of the area.

Paddayya identified the main features of the Hunsgi valley Acheulian industry by studying the typological composition of 13 surface assemblages (including the one from the trial excavation at Hunsgi III) and two from excavation (Localities V and VI at Hunsgi) (Paddayya, 1977). He follows the classifications suggested by Kleindienst (1962), Clark (1967), and Leakey (1971), which divide each assemblage into three groups: shaped tools, utilized pieces, and *debitage*.

A detailed study was made of the assemblage from Trench 3, Locality V near Hunsgi. Here Paddayya found 291 artifacts from the excavation, shaped tools (109 pieces, 37.44%), utilized pieces (25 pieces, 8.61%), and *debitage* (157 pieces, 53.95%). The density of artifacts is 13 pieces per square meter, the density of shaped tools is 4.8 pieces per square meter. There are 262 (90%) specimens made of limestone, the others are made of chert, sandstone, quartzite, dolerite, epidosite, gneiss, and phyllite. The specimens of each group are further classified into various artifact types. In the Shaped Tools group, there are Cleavers (28 pieces, 25.69%), Handaxes (18 pieces, 16.51 %), Knives (14 pieces, 12,84%), Choppers (9 pieces, 8.26%),

Picks (8 pieces, 7.34%), Polyhedrons (10 pieces, 9.17%), Spheroids (4 pieces, 3.67%), Scrapers (15 pieces, 13.67%), Flakes with prepared butts (2 pieces, 1.83%), and Backed tools (1 piece, 0.92%). In the Utilized Pieces group, there are Anvil stones (3 pieces, 12%), Hammerstones (5 pieces, 20%), Utilized flakes (15 pieces, 60%), and Utilized tabular pieces (2 pieces, 8%). In the *Debitage* group, there are Cores (5 pieces, 3%), Indeterminately worked nuclei (20 pieces, 13%), Flakes (5 pieces, 3%), and Waste products (127 pieces, 81%). The main features of the industry are as follows: This is the only Lower Paleolithic site in India where limestone was used to make tools; there are more waste products than shaped tools on the floor, where anvils and hammerstones strengthen the view that the horizon is in its primary archaeological context and that the manufacture of tools took place on this location. Finally, the high percentage of cleavers and handaxes identifies the Acheulian character of the assemblage of the entire Hunsgi floor.

The Collection

I was given permission to work with all of Paddayya's collections from the excavations at Localities V and VI. The collections were sorted into categories, each in a separate drawer at the warehouse. I recorded 20 examples (2 typical specimens from each category that was classified by Paddayya) for Trench III, Locality V, and I also recorded 3

examples from the Trench I, Locality VI, to double check my findings (Table 8). Most of the specimens recorded are in fresh condition.

<u>Core with one bifacial leaf-shaped end [C13] (5 specimens)</u>

All the specimens are made on elongated limestone blanks (slab pieces and cobbles). Specimens have sharply pointed tips and are relatively broad at the butt ends, the outline tending to be oblong-triangular. The specimen profiles are generally long and narrow. In many specimens, the tips and anterior parts are lozenge-shaped in cross-section with longitudinal ridges on both faces formed by the intersection of the trimming scars on either edge. The massive butts of specimens Tr.3:45 and Tr.3:35 retain 33 and 25 per cent of cortex, which was unworked. Both lateral edges of Tr.3:45 are carefully trimmed with an equal amount of flaking on the upper and lower faces, the flake scars being small and even. The anterior part is comparatively narrower than the other specimens, like a drill. Edge damage is concentrated on the point. The length/breadth/thickness measurements are 174x100x42 mm., the weight is 800 gm. (Fig. VIII 12).

On specimen Tr.3:35, one of the lateral edges of the lower face and the upper face are trimmed extending to the proximal end, but the other lateral edge of the lower face is trimmed only half way up the edge. The

length/breadth/thickness measurements are 210x110x66 mm., the weight is 1,500 gm. (Fig. VIII 13).

Ninety-five per cent of the circumferences of specimens Tr.3:34 and Tr.1:17 is trimmed bifacially. Thirty-three percent cortex remains on the central part of one face on both specimens. The flake scars are uneven, some of them are deeper than others, and they are trimmed in irregular directions. Edge damage is concentrated on the lateral edges. The length/breadth/thickness measurements of Tr.3:34 are 167x95x37 mm., of Tr.1:17 are 159x85x52 mm., the weight of Tr.3:34 is 650 gm. (Fig. VIII 12), of Tr.1:17 is 800 gm. (Fig. VIII 14).

There is no cortex on specimen Tr.3:32. The trimming scars are comparatively shallow and in varied sizes. Edge damage is concentrated on the point. The length/breadth/thickness measurements are 132x78x45 mm., and the weight is 500 gm. (Fig. VIII 13).

<u>Core with two bifacial leaf-shaped ends [C14] (1 specimen)</u>

Specimen Tr.3:29 is made on an oblong, limestone slab. One end of the tool is damaged. There is 20 per cent cortex remaining on the central part of one face, the other face is trimmed along most of both lateral edges. Hence, more than 60 per cent of the circumference is bifacially trimmed. The flake scars are large and shallow. The cross-section is quite biconvex. Because one extremity is broken, we cannot

see the original shape, but from its symmetrical tendency, we would expect the ends to resemble each other. Edge damage is present on the lateral edges and on the points. The remaining length/breadth/thickness measurements are 202x87x63 mm., the weight is 1,200 gm (Fig. VIII 14).

Core with all bifacial edges [C15] (2 specimens)

Specimens Tr.3:42 and Tr.3:108 are made on sub-angular limestone cobbles. The uneven flake scars cover the entire circumference on both faces, and there is no cortex. The edges are sharp, and the central part is much thicker than the perimeter. There is edge damage present on all the edges. The length/breadth/thickness measurements of Tr.3:42 are 98x77x60 mm., of Tr.3:108 they are 77x73x32 mm. The weight of Tr.3:42 is 600 gm. (Fig. VIII 15), and Tr.3:108 weighs 300 gm. (Fig. VIII 15).

Core tool in other shapes [C17] (4 specimens)

Tr.1:262 is made on a granite cobble, but the other specimens are made on limestone blocks. There is cortex on each specimen, but in varying percentages. Some specimens are weathered, with calcium cemented material on top. Specimens Tr.3:83 and Tr.3:77 are made on sub-angular blocks. The edge damage is present on a single edge only. The length/breadth/thickness measurements of Tr.3:83 are 88x74x69 mm., of Tr.3:77 are 109x108x100 mm. The weight of

Tr.3:83 is 500 gm. (Fig. VIII 15), Tr.3:77 weighs 1,250 gm. (Fig. VIII 16).

Specimens Tr.1:262 and Tr.1:3 are made on sub-rounded cobbles. There is 50 per cent cortex remaining on each specimen, and edge damage is present on all the edges and the cortex. The length/breadth/thickness measurements of Tr.1:262 are 84x74x58 mm., of Tr.1:3 are 192x88x84 mm. The weight of Tr.1:262 is 450 gm. (Fig. VIII 16), of Tr.1:3 is 750 gm. (Fig. VIII 16).

Flake with double lateral unifacial edges [F2] (5 specimens)

Specimens Tr.3:52 and Tr.3:56 are made on oblong limestone flakes. The butt ends are formed by flat vertical surfaces, oblique to the lengths of the tools. Double lateral edges are sharp and jagged, they also show edge damage. The distal edges on each tool are tongue-shaped, primary flake surfaces; they have not been trimmed. The bulbs of percussion are generally pronounced, and extend across the whole width of the flake. There is no cortex on either specimen. Both lateral edges of specimen Tr.3:52 are made from ventral face to dorsal, but one of them was trimmed only on the area next to the proximal end. The length/breadth/thickness measurements are 158x81x43 mm., the thickness and breadth of the platform are 30x56 mm., the angle of the platform is 128 degrees, the weight is 800 gm. (Fig. VIII 17).

There are several previous flake scars on the dorsal face of specimen Tr.3:56, and both lateral edges are made from dorsal face to ventral. The trimming scars are comparatively deeper on the edges. The length/breadth/thickness measurements are 135x73x34 mm., the thickness and breadth of the platform are 25x41 mm., the angle of the platform is 135 degrees, the weight is 200 gm. (Fig. VIII 17).

Specimens Tr.3:28, Tr.3:24, and Tr.3:20 are made on limestone flakes. Although the shapes of the flakes are different, all vertical distal edges are basically perpendicular to both lateral edges. The distal edge is the primary surface on each specimen, there is no retouch work. The distal edges are jagged, and exhibit edge damage. The bulbs of percussion are pronounced, and there is no cortex remaining on any of these specimens.

There is a ridge of two surfaces that join each other on the platform of specimen Tr.3:28. This may indicate that the flake was originally taken off from a corner of the slab. The bulb of percussion is not under this ridge, but under the surface of the platform. There are several previous transverse flake scars on the dorsal face. Double lateral edges follow the same curved outline, the proximal end is not parallel to the distal end. Both lateral edges are made from ventral face to dorsal. The length/breadth/thickness measurements are 128x90x48 mm., the

thickness and breadth of the platform are 36x63 mm., the angle of the platform is 120 degrees, and the weight is 450 gm. (Fig. VIII 18).

On specimen Tr.3:24, the width of the proximal end is only half the width of the distal edge. Both lateral edges are unifacially made but are made from opposite directions: one is from ventral face to dorsal, the other is the opposite. The trimming scars are deeper near the edges. The length/breadth/thickness measurements are 114x70x34 mm., the thickness and breadth of the platform are 12x24 mm., the angle of the platform is 115 degrees, and the weight is 400 gm. (Fig. VIII 18).

Specimen Tr.3:20 is roughly rectangular in shape. The bulb of percussion is under the ridge of two flake scars that join each other on the platform. There are trimming scars on the proximal end and both lateral edges, which are from ventral face to dorsal. Still, the proximal portion is much thicker than the distal portion. The length/breadth/thickness measurements are 116x78x46 mm., the thickness and breadth of the platform are 46x46 mm., the angle of the platform is 125 degrees, and the weight is 600 gm. (Fig. VIII 19).

<u>Flake with unifacial distal end [F7] (1 specimen)</u>

Specimen Tr.3:271 is made on a thin limestone flake. There is no cortex. The proximal end is parallel to the

distal edge. The breadth of the distal edge is twice that of the proximal end. There are previous flake scars on the dorsal face. The distal edge is trimmed from ventral face to dorsal unifacially, with some deep scars. The angle of the distal edge is about 60 degrees. The bulb of percussion is marked. There is edge damage present on the distal edge and on a concave lateral edge. The length/breadth/thickness measurements are 80x62x17 mm., the thickness and breadth of the platform are 17x21 mm., the angle of the platform is 125 degrees, and the weight is 150 gm. (Fig. VIII 19).

Flake with all unifacial edges [F10] (2 specimens)

Both specimens are made on thick limestone flakes. Both are oblong, and the portion with the most breadth and thickness is located one fourth of the length from the proximal end. The trimming scars are around the entire edge, which is from ventral face to dorsal. The bulbs of percussion are marked on both tools. The platform of Tr.3:127 is a flat surface, vertical to the length of the tool. There is cortex on the central part of the dorsal face. The flake scars are large and shallow. There is edge damage present on the double lateral edges and distal edge. The length/breadth/thickness measurements are 110x71x40 mm., the thickness and breadth of the platform are 28x32 mm., the angle of the platform is 90 degrees, and the weight is 300 gm. (Fig. VIII 19).

The point of Tr.3:36 is damaged. There is no cortex remaining. The uneven flake scars cover the entire dorsal face, including the back of the platform. There is edge damage present on all the edges. The remaining length/breadth/thickness measurements are 136x109x50 mm., the thickness and breadth of the platform are 31x60 mm., the angle of the platform is 105 degrees, and the weight is 650 gm. (Fig. VIII 20).

Flake with double lateral bifacial edges [F13] (1 specimen)

Specimen Tr.3:27 is made on a rectangular limestone flake. There is cortex remaining on the central part of the dorsal face. The profile is roughly a right-angled shape, hence the proximal end is quite thick and the distal edge is sharp. There is also a retouch scar on the platform. Both lateral edges are parallel, and made bifacially. The trimming scars are comparatively even; the edge damage is present only on the distal edge. The length/breadth/thickness measurements are 158x99x44 mm., the thickness and breadth of the platform are 40x55 mm., the angle of the platform is 115 degrees, and the weight is 900 gm. (Fig. VIII 20).

Unmodified flake [U1] (1 specimen)

Specimen Tr.3:53 is made on a large limestone flake. The width of the flake is greater than its length (1.6:1),

and there is no cortex remaining. The proximal end is thicker than the distal edge; natural surface remains on both dorsal and ventral faces; the distal edge is a convex curve and is jagged from damage. The bulb of percussion is pronounced and is quite wide. The length/breadth/thickness measurements are 90x146x40 mm., the thickness and breadth of the platform are 40x76 mm., the angle of the platform is 120 degrees, and the weight is 700 gm. (Fig. VIII 21).

Debitage flake [D1] (1 specimen)

Specimen Tr.3:272 is a complete limestone flake. There is 0.125 per cent of cortex remaining on the distal part of the dorsal face, where there are several previous flake scars remaining. The bulb of percussion is pronounced. There is no damage present on the edge. The length/breadth/thickness measurements are 57x41x15 mm., the thickness and breadth of the platform are 15x22 mm., the angle of the platform is 90 degrees, and the weight is 50 gm. (Fig. VIII 21).

3. Analysis and Replication

Technology

The raw materials selected to make these 23 stone tools are limestone (95%) and granite (5%). There is cortex remaining on the only granite tool (50%). Among the limestone tools, 11 have various amounts of cortex

remaining, ranging from 12.5 to 50 percent, with an average of 24 percent. Eleven of them lack cortex altogether. About half of the specimens have cortex, but the percentage of cortex on each tool is low.

There are 12 core tools in the collection (52%). This percentage is close to the proportion between cores and flakes in Trench 3, Locality V at Hunsgi. Excluding the Waste Products (127 pieces) in the Trench 3 collection leaves 164 specimens. Eighty (49%) of them are core specimens, and 84 (51%) are flake specimens.

The length/breadth/thickness measurements of the core specimens range from 210x110x66 mm. to 77x73x32 mm., with an average of 141x87x59 mm. These numbers indicate that most of the limestone slabs from which the cores were obtained were oblong or rectangular. The average of the tool lengths is 1.6 times the average breadth. The core tools are comparatively thick in the central part, and their weights range from 1,500 gm. to 300 gm., with an average of 775 gm. The numbers of flake scars on the cores range from 38 to 5, with an average of 19. This suggests that, in most cases, the flake scars are small, and flintnappers used each piece of raw material fully. All the core tools in the study were produced bifacially.

There are 11 flakes in the study sample. The length/breadth/thickness measurements range from 158x99x44 mm. to 57x41x15 mm., with an average of 116x84x37 mm. With

one exception the specimens are longer than they are wide. The platform thicknesses range from 46 to 12 mm., with an average of 29 mm; platform breadths range from 76 to 21 mm., with an average of 45 mm. The ratio of thickness to breadth of platform is 1:1.6. There are 2 specimens (Tr.3:28 and Tr.3:20) that have two flake scars on the platform, the rest of the flake specimens have no flake scars or cortex on the platforms. This may explain why the butt ends of the flake specimens are usually formed by a flat, vertical surface, either transverse (the angle of the platform of Tr.3:127 and Tr.3:272 is 90 degrees) or oblique, to the length of the tools. The weights range from 900 to 50 gm., with an average of 472 gm. There is quite a difference in average length, thickness, and weight between the flake specimens and the core specimens, but there is not much difference in the breadth (87:84). This may suggest that some flakes were taken off the face (upper or lower) of the slab, rather than from the sides. Due to the thick platform available (the ratio of average thickness of the platform to the average thickness of the flake specimens is 1:1.2), these flakes usually have widths, similar to those of the original slabs.

There is only one flake specimen (Tr.3:27) made bifacially. Eight other specimens are made unifacially: Tr.3:56 is flaked from dorsal face to ventral, Tr.3:24 is alternately retouched on both lateral edges, and the rest of the specimens are made from ventral face to dorsal. This

phenomenon of unifacial flaking on flakes compared to cores, which are all made bifacially, is noteworthy. This pattern may be a distinctive technique characteristic of ancient flintknappers in the Hunsgi valley.

Selection of Lithic Raw Material

As noted, 90 per cent of the specimens of Trench 3 at Hunsgi V are made of limestone. Because the limestone formed the main portion of the valley floor, limestone resources for ancient flintknappers are not only those from the limesone plateau that is 2-3 km. north of the Locality V, but from everywhere along the valley floor. At the time of my fieldwork there were plentiful chunks or cobbles of limestone and granite among the ploughed fields of the valley (Fig. VIII 22).

Mr. Basappa, a teacher at the Hunsgi village local school, has helped Paddayya since 1974 in the investigation of the area. He knows all the Localities very well, and guided me around the valley for two days (Fig. VIII 23). He showed me most localities on the floor, and the distribution of the resources of various kinds of raw materials. There were stone tools everywhere. The Hunsgi valley was dry and hot in the winter and was covered with thorny, scrub-forest vegetation reflecting the semi-arid climate. Nevertheless, swarms of mosquitos appeared as soon as the sun set. Hence the only time to work is from sunrise to sunset.

There are many limestone blocks or slabs that have been gathered in the recent past from the limestone plateau (in the immediate vicinity) and brought to the valley for use as material to make walls. The limestone was very fresh and in varying sizes (Fig. VIII 24). There was a local farmer working on the limestone slabs with an iron hammer and hammer drill. He took irregular chunks or slabs and made them into regular parallelepipeds (cuboids) by shaping the edges (Fig. VIII 24).

I collected and measured about 10 blocks or slabs from one of the groups of limestone that had been collected for shaping into blocks suitable for wall construction. The length/breadth/thickness measurements range from 280x260x94 mm., to 96x75x48 mm., with an average of 234x165x75 mm. (Fig. VIII 25). The weights of these raw materials range from 2,200 gm. to 315 gm., with an average of 1,180 gm. These averages are much greater than the average measurements and weights for core specimens (141x87x59 mm., and 775 gm.), and flake specimens (116x84x37 mm., and 472 gm.). This is because the shapes of these limestone slabs are quite different from the shapes of any specimens from the collection. As noted, the average number of flake scars on each core specimen is 19, and taking off this many flakes substantially reduces the size of the raw material. Most of the materials I collected were longer than they were wide. Through observing the thickness of the gathered limestone

slabs, and talking to the local people, one concludes that the limestone usually breaks down in large layers about 10-30 cm. thick, more often between 10-20 cm. thick. Because the limestone material was quarried from the tableland, all the fragments have one or two flat, wide surfaces.

There are still many granite cobbles on the valley floor that can be used as hammerstones. I used 7 of these hammerstones to finish my work. The length/breadth/thickness measurements range from 174x132x120 mm. to 114x108x102 mm., with an average of 154x120x93 mm. The weights of the hammerstones range from 3,445 to 1,364 gm., with an average of 2,203 gm. (Fig. VIII 26).

Reduction Sequence

Local farmers usually put the large chunks of limestone on the ground, and use indirect percussion to take flakes off the circumference of the two upper and lower faces. But the 3 limestone anvils found in trench 3 at Hunsgi site may have been used by the ancient knappers to support their limestone cores. The beginning stages of flaking are much easier if one uses such a support. When I put the core-slab directly on the ground, I could not remove large flakes; I was able only to chip off some small flakes. It was only when I put a piece of flat limestone under the worked piece to raise the working level that the process became more comfortable. Using my left thigh to support the stone was

even easier for me. The limestone is not soft, rather it is brittle but hard. Strength is needed to break a large slab, but it is possible to take off large flakes by free hand percussion in different directions.

There are two sub-rectangular limestone tools in the collection, which are Core with all bifacial edges (Tr.3:45 and Tr.3:108). In order to replicate this kind of tool, I started with a large, thick slab. The length/breadth/thickness measurements are 280x194x117 mm., and the weight is 1,680 gm. I trimmed 8 large flakes off bifacially from the entire circumference (Fig. VIII 26). There were over 100 pieces of flakes as debitage, but they were in various sizes (Fig. VIII 27). The final shape of the tool was sub-rounded. The length/breadth/thickness measurements are 80x64x51 mm., and the weight is 400 gm. (Fig. VIII 28). The time required was from 8:41 -8:54 am, only 13 minutes. The fastest way was to start from one of the square corners of one surface, then from the other on the same edge, alternating to get a sharp edge. Using the same technique, but this time trimming a type of Core with one bifacial leaf-shaped end, which results in a massive butt with a sharp point, took only 15 minutes (Fig. VIII 29). There are 5 examples of these kinds of tools in the collection: Tr.3:34, Tr.3:45, Tr.3:35, Tr.2:17 and Tr.3:32.

Most of the flakes that were trimmed on the roughing-out step (taking the outer cortex off) were thicker, with a

flat and wide platform and natural sharp edges all the way around. These basically retain different percentages of cortex on the dorsal face (Fig. VIII 30). Using these flakes, I trimmed both lateral edges parallel, starting from the dorsal face on one edge and from the ventral face on the other edge (alternate). This replication work led to the type of Flake with unifacial double laterals in other shapes. The example of this type in the collection is specimen Tr.3:24. However, one can also trim both parallel lateral edges bifacially to replicate the type Flake with double lateral bifacial edges (Fig. VIII 31). The example of this type in the collection is specimen Tr.3:27.

Overall, the replication work tested and verified that the quarried limestone used by the flintknappers in Hunsgi was basically slab or block shaped. This available raw material determined the technique (hammer method) and main types of the stone tool assemblage. Because the limestone slabs were more or less flat (usually 10-20 mm. thick), bifacially trimming from the corner of one extreme end to the other end, would produce the thick platform with a sharp natural distal edge, and leave a core with a sharp edge but very thick centrally. This phenomenon can explain the characteristics of both the core and flake tools from Trench 3, Hunsgi V. When neither lateral edge of the flake is very thick, unifacial trimming would be the best way to produce sharp edges. That is doubtless why all the core specimens

in the present study were made bifacially, whereas the flake specimens were made unifacially.

The size of the quarried slabs must have been much larger than either the core or the flake specimens in the collection. The result of replication work for Tr.3:45 (<u>Core with all bifacial edges</u>) shows a reduction in the size and weight of the replicated tool by more than half. There were 8 large flakes and over 100 pieces of debitage produced in the process. This result answers two questions about the lithic collection: Why is the average number of flake scars on each core specimen so large (19)? Why is the quantity of debitage from Trench 3, Locality V, more than half the total number of the artifacts (157:291) from the excavation? Another relevant factor is the quality of the limestone, which is hard and brittle. Small, thin flakes are quite easy to produce in the finishing step (shaping the tool). It should also be noted that, due to the quality of the limestone, not even the limestone nuclei could be used as hammerstones.

Chapter 10 Summary, Discussion, and Conclusions

The data in this study come from eight Lower Paleolithic assemblages, dating from 1.1 million to 150,000 years ago. The material collected provides the basis for a thorough reconsideration of the Paleolithic period in Southern and Eastern Asia. It also suggests a number of inferences about Middle Pleistocene knappers and their technologies.

The findings from these eight sites are brought together in the following summaries.

1. Chronology

Reliable chronological placement for each of the eight sites is supported by consistent stratigraphy, well preserved fossiliferous Pleistocene deposits (hominid remains or mammalian fauna) associated directly with stone tool assemblages or with a nearby environment of the same stratigraphic age that contains fossiliferous deposits suitable for dating. The association of stone tools and fauna does not, however, mean that the bones represent food waste. Without a taphonomic study it is not possible to make conclusive statements about human activity concerning the tools and fauna. Nevertheless, these associations serve to date the stone tools.

At three localities (Lantian, Shilongtou, and Guanyindong), stone tools were found in association with fauna. At four localities (Liangshan, Bose, Durkadi, and Hunsgi) faunal remains were found separate from the tools, but nearby and in the same stratigraphic level. Bhimbetka is the only locality where stratigraphic dating must be used for the Lower Paleolithic artifacts in the study.

Fossil mammal assemblages in China are somewhat different from those of the Indian assemblages. The five mammalian faunal assemblages (each faunal assemblage contains various numbers of species, ranging from 9 to 25, with an average of 13 species) found in China all belong to the *Ailuropoda-Stegodon* complex of the Middle Pleistocene. These five localities stretch between a northern boundary at 34.18 degrees north latitude (Lantian), to a southern boundary at 23.30-23.60 north latitude (Bose). The *Stegodon-Ailuropoda* faunal complex is described as a "group of forest mammals [who] lived in a comparatively warm and humid climate" (Hu, 1978:52). Nevertheless, there are minor differences among the faunal localities that correlate with paleogeographic distribution. Hydrophilous species, for example, are absent in the Lantian faunal complex, but fairly abundant in the Guanyindong faunal complex. These mammalian assemblages indicate the ecological conditions prevailing for hominids in the area during the Middle Pleistocene.

This environmental situation is quite different from that of modern China. The Qinling Mountains. (about 33-34 degrees north latitude) are regarded by most geographers today as the line of demarcation between the Yellow River and the Yangtze River regions, or, more generally, between north and south China. The average height of the Qinling Mountains. is presently 2,000 meters above sea level. They serve as a barrier to the encroachment of cold air from northern China, and as a wall sealing in the warm air of southern China. The mean January temperature of the southern Qinling slopes is approximately -1 to -3 degrees, while the northern Qinling slopes is -3 to -10 degrees centigrade, with a reduction in mean annual temperature of approximately 3 to 7 degrees centigrade. An indication of what this means is that at present the giant panda is present only in the mountain region between Sichuan and Shaanxi Provinces of the southern Qinling, but during the Middle Pleistocene they existed north of the Qinling as well.

By comparison, in the first interglacial stage, the Qinling Mountains. were not as high as they are presently. Although there is no way to know their exact height during the Paleolithic period in question, the warm monsoon most likely extended further northward over the mountains in the summer. It is not very difficult to find evidence of such climatic conditions in the Quaternary sediments. According

to paleoenvironmental studies in China, the phenomenon of the red clay (one of the earliest deposits, indicating a warm and moist environment) retreated southward and spread mainly south of the Qinling and Huai river (latitude 32 degrees north) in the Early Pleistocene. In the Middle Pleistocene, the red clay extended northward, up to a line between Beijing and Yingkou (latitude 40 degrees north). Following this climatic change, *Ailuropoda-Stegodon* fauna was present in the southern area during the Early Pleistocene. However, it moved north, crossing the Qinling, and reaching Lantian, Shaanxi province and the Beijing area in the Middle Pleistocene (Liu, 1983). The result of these multiple climatic fluctuations during the Quaternary and the migration of fauna is reflected in the mammalian remains at the five archaeological localities in China.

Compared to the situation in China, there are fewer mammalian species from the boulder conglomerate / red clay deposits of the Narmada Valley lower gravels in India. The species found include *Hexaprotodon namadicus*, *Bos namadicus*, *Equus namadicus*, *Stegodon insignis*, and *Elephas* (Badam, 1984). This faunal complex from the late Middle Pleistocene is related to the Durkadi site on the southern bank of the Narmada River. According to G.L. Badam's study, there has been no significant departure from the existing tropical climate in the area; therefore the valley provided a favorable ecosystem for Pleistocene hominids. Two species,

Bos namadicus and *Equus namadicus*, were found in the Hunsgi valley and are similar in size and characteristics to those from the Narmada River valley. *Bubalus* is also present in the collection from the occupation site. Badam suggests that this faunal assemblage indicates that the area possessed a savanna woodland type of vegetation and large bodies of standing water during the period of hominid activities (Paddayya, 1985).

There are two finds of hominid remains in these eight sites: one at Lantian (*Homo erectus lantianensis*) has been found associated with stone artifacts; the other is in the Narmada valley (*Homo erectus* or archaic *sapiens*) near Hathnora, Madhya Pradesh, in the same stratigraphic level as the stone tools in the Durkadi Nala. Discoveries of fossiliferous Pleistocene deposits not only provide firm evidence of the time period involved, but also tell us something about the living conditions of *Homo erectus* who made the stone tools in the Lower Paleolithic period.

The absolute dating of the Lower Paleolithic deposits by the stratigraphy of those four sites has been generally accepted. According to the magnetic boundary ages and estimates of the depositional rate of loess, the age of the Lantian hominids found at Gongwangling is about 1.1-1.15 myr. Uranium-series dating puts the layer of stalagmitic crust in Guanyindong (Group B) at 230,000 y BP. Paleomagnetic dating of the lateritized terrace of the lower

Yangtze River, a terrace similar to the lateritized terrace that contained the Bose artifacts in Guangxi, dates to 0.9-1.1 my BP or 0.8-0.9 my BP. Uranium-series dates for three travertine samples resulting from fossil spring activity in the Hunsgi valley give a corrected age of 174,000 (+/-) 35,000 years and an uncorrected age of 166,000 + 15,000/ - 13,000 years. These dates further strengthen the chronological placement of eight study sites are in the *Homo erectus's* period.

As noted, the association of stone tools and fauna can provide relative dates for the eight archaeological sites. Moreover, hominid fossils found in the same stratigraphic level as stone tools and mammal remains can further substantiate the chronology of the deposits. Absolute dating of the geological deposits provides even further evidence for chronological placement.

2. The Occupation Sites

As with most Lower Paleolithic sites, the eight assemblages selected for this project were recovered from three different geologic contexts: (1) sedimentary deposits formed along ancient river systems -- Lantian (Ba River), Liangshan (Hanshui River), Bose (You River), and Durkadi (Narmada River); (2) cave-deposits -- Shilongtou (limestone cave), Guanyindong (limestone cave), and Bhimbetka

(sedimentary rock shelter); and (3) continental basin sedimentation -- Hunsgi.

Although these subdivisions are based on the general geological features of each site, the geological conditions and depositional formations at each site are subject to many local variations. For example, Bose can also be described as a succession of pediment basins (or red bed basins in the Lower Cenozoic) in the Guangxi area. The Shilongtou limestone cave is adjacent to Daye Lake, and the lowest level of the cave is about 10 m. above the dry season level of Daye Lake. Hence, the cave deposit formation may parallel the Pliocene lake basin deposits of the area. The Hunsgi valley basin was originally an erosional surface, thus it might be Late Pliocene. Another important aspect of the geology of the Hunsgi area concerns several springs in the Hunsgi valley, which, with the adjoining Baichbal valley, formed the headwater zone of the Hunsgi stream, one of the minor left-bank tributaries of the Krishna River. The occupation floors of the sites were basically on the banks of the stream. Hence, the antiquity of artesian springs and streams also contributed to the site's formation. The sediments deposited in different environments can be correlated, thus allowing a rather detailed paleogeographic reconstruction for each geologic setting. All the occupation sites in this study were

situated close to water, either by a lake shore or by rivers and streams (see detail in each chapter).

The composition of the stone artifact assemblages makes it clear that pieces (cores, flakes and debitage) were probably removed from each of these eight archaeological sites. This can happen when early knappers carry away core or flake tools when leaving the site, or later during and after the site's transition to the archaeological context. I was unable to conjoin or fit pieces of any stone artifacts together in any of the assemblages, although in some of the sites there remain a few debitage items and unmodified pieces (Lantian, Liangshan, Guanyindong, and Hunsgi). Hence, the present study depends upon the original excavation report as the primary indication of site structure and the degree of disturbance. Occasionally I was able to observe traces on the tools themselves (rounding, etc.) that provided some information about possible sources and amount of disturbance. Each site's special situation is described in individual detail, chapter by chapter.

The final deposition and burial of artifacts results from one or more of the various forces that act upon sites in various environments (floodplain, lakeshore, cave, or eolian deposit). Recent studies of the formation of archaeological residues have described a large number of site patterns caused by natural processes and their effect

on material residues in archaeological sites (Schick, 1986). While it remains unclear whether discard behavior had developed during the Lower Paleolithic period, Schick thinks that it is reasonable to assume during "the earliest phases of prehistory, when there is little solid evidence of structures or of long-term site occupation, that much of the material found at archaeological sites had been deposited or discarded at the location of use, i.e., represents primary refuse" (Schick, 1986:164). Although the eight sites in my study were certainly affected by a variety of environmental processes, if Schick is correct, then the tool assemblages from those sites are nevertheless good indicators of the technological achievements of their hominid makers.

Because there have been only a few taphonomic studies of the mammalian fauna (You, 1989), and no use-wear studies on the stone tools, it is impossible to state precisely the relationship between the hominid and animal fauna found in the sites. Nor is it possible to say exactly how the hominids used the stone tools. Judging by the distribution of the stone tool assemblages and their surrounding remains on the surface floor, however, as well as the vertical distribution of the deposits, I think two of the occupation levels in this study consist of living floors: Bhimbetka and Hunsgi. Two other sets of occupation levels contain knapping areas: Guanyindong and Durkadi. That interpretation is indicated at these two sites because of

the distribution of debitage (flakes and fragments) together with stone artifacts. The Shilongtou fossils are quite fragmented, and are associated with the artifact distribution within a 0.3-1 meter thick yellow and brown sandy clay deposit of the second layer in the cave. This cave site occupation could have been used in many different ways: as a dwelling, or a place for knapping stones, and/or for butchering small pieces of meat.

Lantian is an open-site that contains hominid and animal fossils and stone tools in a single layer (2 meters thick). Because there have been no other kinds of human fossils found in the Lantian area, *Homo erectus lantianensis* is the only species considered to have made stone tools at Lantian. Liangshan and Bose are also occupation open-sites, their most distinctive characteristics being the thickness of the stratum containing the stone tools (1-2 m. thick at Liangshan, 4 m. thick at Bose), and the even thicker deposits overlying them (about 8 m. in both sites). There are no mammalian fauna directly associated with the stone tools, but bones are present near the tools. Moreover, sites where high densities and large quantities of artifacts (stone tools made of the same raw material and in similar types) were found on the surface are distributed in a large area (28 localities in Liangshan, and 100 localities in Bose). These three open sites are difficult to interpret. The lush river valley presumably provided favorable living

conditions for hominids, but careful study of their stone artifact assemblages should help us understand the problems they confronted in survival. It is unlikely that all subsistence activities required the use of stone tools; hands or wooden sticks could have been used to gather plant food, for example. Activities occurring in the areas close to the river may have required the repeated making, use, and discarding of tools that then come to form concentrated patches. Perhaps they made stone tools here or wherever necessary, and ranged throughout these areas, from river valley to uplands, without establishing home-bases or lived in simple shelters near to the river.

The stone objects found in each of these sites bear signs of edge damage, but there are no studies as yet of microscopic wear-patterns, so it is not possible to say exactly what activities were performed with these tools. To interpret prehistoric activities from the archaeological evidence, one must consider the interaction of natural agencies with human behavior. Beyond these recognized problems, as Schick emphasizes, it is not always clear what kinds of behaviors caused the development of fairly concentrated deposits of stone artifacts, particularly in the early record. In my study of the 8 sites, I follow the interpretations of the excavators. If no suggestions are provided by the excavators, then I discuss as many

alternative explanations of the site occupation as seem plausible to me.

3. The Lithic Industries

Although recent work on site formation and early human behavior tends to focus on animal bones (e.g., Binford, 1981), the stone artifacts can also provide some information about taphonomy and early hominid behavior. In fact, there are very few functional studies of Lower Paleolithic artifacts. Keeley and Toth (1981) examined 56 stone artifacts (made of fine-grained siliceous rocks) from Koobi Fora (1.5 Ma) under the microscope. Only 9 of these had clear traces of microscopic wear: 4 from contact with meat, 5 from cutting, sawing, and scraping plant matter. None of the Olduvai artifacts has been subjected to this kind of edge wear analysis, largely because these tools are made of quartzite, which is not amenable to such analysis (Sussman's personal communication with Potts in 1986; see also Potts 1988).

Nevertheless, lithic assemblages can provide useful information. The most obvious information is about the lifeways of the people who made and used the tools. This dissertation is based on the representive typological and technological characteristics of selected specimens. Four assemblage samples are from excavated sites (Shilongtou, Guangyingdong, Bhimbetka, and Hunsgi). Another four

assemblage samples contain both excavated and surface specimens (Lantian, Liangshan, Durkadi, and Bose). When information from excavation is available, the excavation stratigraphy may indicate the topographic features of the area. Surface specimens were usually exposed by the erosion of the laterite, and their technology and types are quite similar to those of the excavated artifacts. The proportion of each assemblage sample to the total number of lithic artifacts from each archaeological site varies, ranging from 1% to 27%, with an average of 8%. Although there are some serious sampling problems (these are discussed in the collection section for each site), the size and diversity of assemblages are sufficient to be representative of the locales from which they came.

Classification

As noted in the Introduction, in the present study I do not follow traditional archaeological classification. Instead I used a reduction typology developed by Flenniken (Flenniken, 1984). The purpose of my lithic analysis is to determine the stages of the tool manufacturing process and the range of forms for each site. After completing the classification of the eight artifact assemblages, I would like to suggest the following advantages of Flenniken's system:

1. Because most of the stone tool assemblages either have not yet, or due to material structure, are not likely to have, use-wear analysis applied to them, such terms as choppers, scrapers, handaxes, cleavers, and so on are generally misleading. The present classification avoids combining terminology based on the form and technique of manufacture with names that imply function.

2. Most investigators (Jones 1978, Isaac, 1984; Potts, 1988; and Toth, 1985), agree that the goals of tool production in Lower Paleolithic times were essentially to form a sharp edge, and both flake tools and core tools were importment. The number of the edges, the distribution of the edges, and the directions of making the edges distinguish one traditional tool type from another. Classification based on the lithic reduction sequence can provide a better picture of the stages of manufacturing for each tool than the traditional classification.

3. The last step of the classification of certain types rests upon the shapes of the tools, such as leaf-shaped or pointed. Tool shape is largely determined by the size, shape, and other features of the original piece of raw material. There are innumerable shapes in nature and unless there was a regular pattern of using raw material of the same shape for the production of the same tool, the shape of the raw material will affect the shape of the tool. According to my observations, most final forms of an early

stone tool are the direct result of the size, shape, and nature of the raw material, assuming that the raw materials were modified in the most practical way possible. There are, however, many irregular shapes resulting from unforeseen fractures in the stone, or simply from mistakes in the flintknapping process. The term "leaf-shaped" describes the general shape of an ovate with an acute tip. This system avoids naming and classifiying many other similar shapes, even those formed as a result of flintknapping mistakes.

By my classification, there are 43 possible types categorized by the stone tool manufacturing process: 23 types are flake tools; 17 are core tools; 3 are debitage; and one is an unmodified flake. The sample of each stone tool assemblage in the study was sorted into these categories of artifacts. The range of artifact types is from 10 to 23, with an average of 14. There are no specimens of the types Flake with unifacial leaf-shaped proximal and distal ends [F6], and Flake with bifacial leaf-shaped proximal and distal ends [F17] in any of the eight archaeological sites. Because all the specimens were trimmed on the proximal and distal ends unifacially or bifacially they are not leaf-shaped, but rather are convex on both ends. When a flake's proximal and distal ends were trimmed into convex shape, these flake tools would be put into the types Flake with unifacial distal and proximal ends

[F9] or Flake with bifacial distal and proximal ends [F20]. The reason there are no types that are unifacial or bifacial leaf-shaped on both distal and proximal ends of one flake is that the length of the flake is not long enough. But similar types are desirable for core tools (Core with two bifacial leaf-shaped ends [C14]). There are also no specimens of the types Core with one unifacial point [C14], and Core with one bifacial point [C12]. The reason there is no real point in the core category is that the frontal portions of the cores are usually too thick and wide to form a point. I did not omit these types (F6, F17, C4, and C12), however, because their absence is also an important characteristic of the assemblage composition.

Raw Material

The issue of lithic raw material differences plays an important role in the study. Hominids treated their raw materials in a variety of ways. They selected raw material that was the best rock available within the shortest distance from the site. Except for the common presence of quartzite, the stone material of each artifact assemblage area is distinctive. By means of thin section analysis (see Appendix 1), the stone material of each assemblage can be grouped into several categories.

(1) Quartzite Assemblages

Of the four archaeological sites where the majority of the stone tool assemblages were made of quartzite (Lantian, Liangshan, Shilongtou, and Durkadi), three (Lantian, Liangshan, and Durkadi) are contemporaneous with nearby ancient river systems. Quartzite is the main element of the ancient river gravels. The distances from the sites to the sources of the quartzite ranges from 200 to 500 meters, with an average of 380 meters.

The other site (Shilongtou) is near to Daye Lake. There is rice growing in the Daye Lake basin today, so it is very possible that the gravels were covered by lacustrine sediments during the Pliocene. If a source of gravel had been left on the shore of Daye Lake, it would have been employed by hominid tool makers, the distance being only 100 meters to the cave site. Today, the ancient gravel layers are exposed only in the river bed of some branches of the Yangtze River (15-20 km. northeast of the cave). Of course, there were smaller amounts of other raw materials, such as quartz and volcanic rock, which were also available in the river gravels. These were sometimes chosen as raw materials by hominid knappers.

The cortex remaining on the quartzite artifacts from these 4 sites ranges from 83 to 100 per cent, with an average of 93 per cent (Fig. 3). The percentage of cortex on each stone specimen ranges from 30 to 46 per cent, with

an average of 41 percent (Fig 4). The ratio between the number of core specimens and flake specimens is 2:1 for Lantian and Liangshan, 1:1 for Shilongtou and Dukadi, the average of this ratio is 1.5:1. These figures suggest that the proportion of core specimens is slightly higher than flake specimens.

The percentage of bifacially made edges in quartzite core specimens is higher than unifacial edges in three stone tool assemblages: 51% bifacial edges to 36% unifacial edges at Liangshan, 75% bifacial edges to 25% unifacial edges at Shilongtou, and 67% bifacial edges to 33% unifacial edges at Durkadi. Lantian is the only site that presents the opposite picture: 83% core specimens made unifacially, and 17% made bifacially. This is very interesting, because the flake specimens in all four quartzite stone tool assemblages contain higher percentages of unifacial edges than bifacial edges. The percent of unifacial edges on flakes compared to bifacial edges in each site is: 89% to 11% in Lantian, 53% to 47% in Liangshan, 100% to 0 in Shilongtou, and 75% to 25% in Durkadi. The average ratio of unifacial to bifacial edges of flake specimens is 3.5:1 in quartzite material sites.

The direction of flaking in these four quartzite assemblages is mostly from ventral face to dorsal, ranging from 67% to 100%, with an average of 81%. The average numbers of flaking scars on the core specimens at each site

are quite similar: Lantian 6, Liangshan 7; Shilongtou 6; and Durkadi 8; with an overall average of 7. The average measurements (length/breadth/thickness) of the core specimens range from 142x115x78 mm. to 82x82x50 mm., with an average of 118x99x65 mm. (Fig. 5). The average weights of the core specimens range from 1,722 gm. to 380 gm. with an average for the four sites of 1,050 gm.

The average measurements (length/breadth/thickness) of the flake specimens in these four sites range from 111x90x34 mm. to 77x69x27 mm., with an average for the four sites of 94x83x33 mm. (Fig. 5). The average weights of the flake specimens range from 541 gm. to 253 gm., with a four - site average of 383 gm. The average percentage of the cortex remaining on the platform ranges from 67% to 30%, with an average of 48% for the four sites. The average platform angles range from 127 to 110 degrees, with an average for the four sites of 115 degrees. The thickness of the platform ranges from 25.5 to 18.4 mm., with a four - site average of 23 mm.

I worked on the quartzite cobbles that were gathered from the current river bank of each site. Based on replication work at these four localities, I concluded that there are several common characteristics of the technology involved in the quartzite artifact assemblages that must be discussed. Quartzite is a granoblastic metamorphic rock consisting mainly of quartz and formed by a

recrystallization of sandstone or chert during a thermal metamorphism (Glossary of Geology, 1972). By referring to the geological thin section analysis of the gravel cobbles that I used to replicate the stone tools from each site, one can see that each quartzite cobble has its own characteristics affecting its tool making potential. For example, there were two quartzite cobbles from the Lantian site. One of them contains not only quartz but also some mica and is therefore interpreted as being "tough because of abundant quartz, mica imparts a planar weakness which will facilitate breaking into flat pieces if fabric is not too strongly developed in which case the rock will be quite weak. A small change in percentage of mica will greatly affect breakability in this sort of rock" (Appendix 1). Another sample analyzed contains a different mineralogical mixture and a different potential for tool making: "Strong interlocking fabric of quartz but may be difficult to shape precisely because of poorly developed mica foliation(s), (layers). May have been very silicaceous igneous rock (at least 65% silica) or feldspar bearing quartzose sandstone" (Appendix 1). Although their outward appearance is similar, these two samples are quite different mineralogically: different in their contents, in the percentage of each mineral, and, just as importantly, in their grain boundaries. These changes directly affect the hardness and the characteristics of fracture of a rock. Hence, a

considerable amount of experience in selecting a suitable cobble for working must have been a prerequisite skill for these early hominid flintknappers.

It was also necessary to choose a certain shape of cobble because that is related to the shape of the final tool. A summing up of the replication work in Lantian shows that 9 of the 28 specimens (32%) are type [C1] (Cores with single unifacial edge), suggesting that hominids chose the most appropriate shape for this type: one side of the cobble thinner than the other. Some even have a triangular cross-section or cylindrical cross-section. Setting the platforms on the thinner side or end of the cobble makes it easier to get the right angle and to produce a comparatively larger flake. The average measurements (length/breadth/thickness) of the flake specimens at Lantian are 111x90x34 mm., which are not much different from the average dimensions of core specimens (142x115x78 mm.). These numbers imply that Lantian hominids were very successful at producing large flakes from large cobbles, something quite difficult to do.

The thickest platform among the Lantian flake specimens is 48 mm. This indicates that the hominid flintknappers set a margin far from the edge of the cobble as a point to strike off a flake. Eighty-two percent of the edges in Lantian stone tool assemblages were made unifacially. Unifacial edges can be just as sharp as bifacial edges on flake tools, and the unifacial technique usually produces a

sharp edge on a flake as well as on the core. Moreover, unifacial trimming usually results in less reduction in the size of the original cobbles than bifacial trimming. The ratio of the dimensions of the quartzite cobbles to the dimensions of the core specimens is 1.6:1, and the average number of flakes taken off the cobble is 6. Hence, the size of the core tools is close to that of the cobbles (Fig. 1). Not many trimming flakes were taken off the cores. This result is related to the fact that the quartzite in the Lantian site is so hard that not much trimming was done.

The quartzite materials at Liangshan are somewhat different from those at Lantian. One sample contained "enough quartz to impart toughness" but the other mineral found in the rock caused either "cohesiveness or weakness". Although the material is as tough as that at Lantian, it contains planar crystals that cause it to fracture unpredictably. Volcanic rocks were also used as raw material at Liangshan, but I could not find any of these for the thin section work.

The sizes and shapes of the cobbles at Liangshan are different from those found at Lantian. They are smaller and rounder, being ovate in plan view. The average dimensions of the cobbles are 167x113x57 mm. (202x132x75 mm. in Lantian), the ratio of the length and breadth of the cobble is 1.5:1. Therefore the cores specimens are restricted in shape, their average dimensions being 117x91x66 mm.; they

are sub-rounded in shape. There are 12 flake specimens (43%) with breadths greater than lengths (the average dimensions of the flake specimens are 83x81x33 mm.); some of these have wide flat platforms with two bulbs of percussion. This characteristic is related to the general ovate shape of the cobble. When there is not much difference between the length and the breadth of the cobble, then wherever one sets the platform on the cobble, the width of the flake should be similar to the length. It has been suggested that the block-on-block technique might have been used to produce some of these kinds of flakes, but I was not very successful in replicating large flakes by using this technique. At present there are no large boulders around the site to serve as anvils.

The unique character of the stone tool assemblage at Liangshan is also related to the ovate shapes of the available cobbles. On 8 of the core tools, flakes were removed from different directions to form a sub-spheroidal tool. The ratio of the average dimensions of the cobbles to the average dimensions of the core specimens at Liangshan is 1.5:1 (Fig. 1). Hence, the sizes of the stone tools did not require significant reduction of the original cobbles.

The quartzite cobbles in Shilongtou are even smaller and rounder than those of the Liangshan site, with average dimensions of 135x104x65 mm. The geological thin section shows the mineralogical makeup to be: "Clean quartz

sandstone heavily cemented with quartz, should be a very uniform and strong rock". Because the texture of the rock is very even and the sorting of its granular structure good, a larger proportion of flakes can be taken off the cobble. The ratio of the average dimensions of the cobbles to the average dimensions of the cores is 2.7:1 (Fig. 1). This number correlates well with the characteristics of the cobbles in Shilongtou. The average dimensions of Shilongtou cores are 82x82x50 mm., and flakes are 77x69x27 mm. (Fig. 5). The reason the lengths and breadths of flakes and cores are so similar is because of the cobble shapes.

Making a tool by alternate technique seems to be distinctive to the Shilongtou industry. Trimming from the dorsal surface on one edge and from the ventral surface on the other edge, or overlapping on one edge, creates a sharp edge. In practice, unifacial and bifacial techniques are by no means mutually exclusive. Which is used usually depends on the most suitable platform and angle for the task at hand. Even the most skilled flintknappers with the most favorable material cannot predetermine the final shape and the direction of striking at each step.

It is difficult to summarize features of the sites where quartzite cobbles are the common raw material because the qualities, sizes, and shapes of the rocks differ. These characteristics of the original raw material directly affect the size, the techniques used, and the forms of the stone

tools produced, as well as the range of variability characterizing each assemblage. Overall, although there are differences among these four stone tool assemblages made on quartzite cobbles, the differences pale into insignificance when compared with the following similarities in technology: (1) the sources of the raw materials; (2) the distances of these raw materials from the sites; (3) the percentage of cortex retained on the tools (Fig. 4), as well as on the platforms; (4) the proportion of core specimens to flake specimens in each assemblage; (5) the use of unifacial or bifacial techniques on the cores and flakes; (6) the number of flake scars on the cores; and (7) the thickness and the angle of the platform.

In the lithic analysis, I grouped together the stone tool assemblages that are made on quartzite cobbles to emphasize the fact that the size, shape, and edge characteristics defining the tool types depends on the size and shape of the raw material, and, further, that the lithic technologies used on the quartzite cobbles are very similar.

Next, I compare the quartzite material assemblages to the silicified limestone assemblage in Bose in order to demonstrate further that the quality of the raw material (rock type) was an important factor for hominid flintknappers.

(2) The Silicified Limestone Assemblage of Bose

Although Bose hominids also lived along the ancient river system and used the river gravels to make stone tools (the same situation as at the sites of Lantian, Liangshan, Shilongtou, and Durkadi), they sought out the most highly silicified limestone cobbles, neglecting the sandstone, quartzite, and quartz that is also present. About 50 percent of the cobbles found in the ancient gravel layers are silicified limestone. The thin section analysis reveals this material to be: "Fine-grained quartz-rich (tough) rock. Has irregular texture and impurities that will disturb uniformity and, thus, breakability. Should hold an edge if sharpening is possible". Although not ideal from the knapper's viewpoint, this kind of raw material is easier to flake than the alternatives, and it also yields sharper edges.

The results of my study show that there are similarities and differences in the technological approaches required for working silicified limestone and quartzite. The similarities are: (1) 100% of the silicified limestone tools from Bose retain cortex (the average of quartzite retaining cortex is 93%) (Fig. 3); (2) a high proportion of cortex remains on both core and flake specimens, 46% at Bose (the average for quartzite material is also 46%); (3) the percentage of cortex remaining on the entire platform is 63% for Bose (48% average for quartzite material) (Fig. 4); (4) the angle of the striking platform is 115 degrees for both

assemblages; (5) the distance from the site to the source of the raw materials is between 300 to 500 meters for both quartzite and silicified limestone assemblages.

The differences between silicified limestone and quartzite assemblages are as follows:

(1) The average number of flake scars on cores is 10 for Bose, which is higher than the average number for quartzite material seven. One thing I have to mention here is that the ratio between the dimensions of the raw material and that of core specimens in the two assemblages is similar: 1.9:1 for the quartzite raw material and 1.5:1 for silicified limestone (Fig. 2). This similarity suggests that the two kinds of raw material required a similar proportion of flakes taken off in order to form a core tool. Bose's core specimens, however, show an average of 10 flake scars, whereas the quartzite core specimens have only 7, so the flakes trimmed from silicified limestone are comparatively smaller than the ones from the quartzite cobbles. The average measurements of Bose flake specimens (length/breadth/thickness) are 174x128x58 mm., the dimensions of the flakes are the same as the dimensions of the cores (Fig. 5). The large flake tools in the study were not trimmed from the cores in the sample studied. They were taken off large cobbles as the end product of tool-making; in other words, the flake was the purpose of the process.

The smaller flakes that were trimmed from the cobbles were lost in the secondary deposit or in some other manner.

(2) The ratio between the number of cores to flakes at Bose is 3.7:1, but in the sites with quartzite raw material it is 1.5:1. This difference in ratio suggests that flakes were more important in the quartzite stone tool assemblages than in the silicified limestone assemblage.

(3) The average weight of the Bose cores is 1,345 gm., which is 1.3 times the average quartzite core weight. But the average weight of silicified limestone flakes is 1,267 gm., which is 3 times the average weight of quartzite flakes. At Bose, the three dimensions of cores are 153x118x72 mm., while flakes are 174x128x58 mm. The average dimensions of quartzite cores in the four quartzite assemblages are 118x99x65 mm., while quartzite flakes are 94x83x33 mm. Again, silicified limestone cores are somewhat larger than quartzite cores, but the sizes of the flakes are quite different. Flake tools at Bose are almost twice as large as those made on quartzite cobbles (Fig. 5). The comparatively heavy and large flakes at Bose indicate that the flakes used here to make tools were the end-product of the tool making process, and not the by-products of tool making as in the quartzite material assemblages. One possible explanation of this phenomenon is that silicified limestone is more brittle than quartzite, allowing large flakes to be struck from the cores.

(4) Seventy percent of the silicified limestone cores were made unifacially, which is just the opposite of the case for the quartzite tool assemblages, where most core tool edges are made bifacially. Furthermore, 71% of the silicified limestone flake tools were made bifacially; again just the opposite of the ratio (3.5:1) between the unifacial and bifacial edges in the quartzite assemblage. Using different techniques to sharpen the edges of the core specimens or flake specimens indicates that these early hominids had the skill required to make stone tools efficiently. It is not necessary to trim a small, thin flake bifacially to get a sharp edge, but it is necessary to trim a large, thick flake bifacially.

(5) The average thickness of flake platforms is 50 mm. at Bose, and 23 mm. in the quartzite assemblages. This number suggests that the margin from the edge of the cobble to the striking point is much wider for the large flake (50 mm.) than for the small flake (23 mm.). There are more core tools than flake tools, but the flake tools are larger than the core tools in the Bose assemblage, indicating that the core tools and flake tools were both produced as ends in themselves. The flakes were not by-products as was the case in the quartzite assemblages. For this purpose, the unifacial technique was usually used on the core tools, and the bifacial technique on the flakes at Bose. My replication work suggests that 10 flakes taken off a

silicified limestone cobble unifacially can trim at least 65% of the circumference, and if done intensively it can make the edges sharp. A large quantity of flakes taken off, especially to make large flakes into tools, requires a uniform, strong rock such as silicified limestone.

(3) The Chert Assemblage of Guanyindong

The best raw material for flintknapping included in this study is chert, which was used in the Guanyindong tool assemblage. Near Guanyindong, Permian-Triassic limestone and shale were present and a karst landscape was well developed. Limestone blanks and chips were plentiful around the cave, but this was not the raw material that the Guanyindong people chose. That is probably because the limestone in the area is quite brittle, and more importantly, there was a source of excellent chert nodules only 4.15 km. from the cave. Although the chert nodules have to be carried farther, and they tend to be harder to flake than limestone, chert edges are the most efficient because they can be made into a sharp edge and are easily resharpend. A piece of this chert examined in thin section showed that the Guanyindong chert contains 100% percent quartz, with practically no irregularities, and should be excellant tool making material. It seems clear the hominids at Guanyindong had a good eye for selecting raw material.

The chert nodules tend to be elliptical. The ratio of the average dimensions (170x130x101 mm.) of the chert

nodules to the average dimensions (64x67x43 mm.) of core specimens is 12:1 (Fig. 2). This is the highest number in the study and means that the original nodules were greatly reduced. When you combine the above with the average dimensions (60x54x22 mm.) of the flake specimens, which are similar to those of the core tools (Fig. 5), and the average number of the flake scars on the core specimens (9), then it appears that each chert nodule was fully used in producing flakes. The figures for the chert tool assemblage are quite different from those for the Bose assemblage: the number of flake tools (27) is 2.7 times that of the core tools (10). Most of the flakes were retouched on the edges, some of them even trimmed on the backs of the platforms, or on the proximal ends. The secondary retouch scars are erratic: some are large and shallow; some are steep and small. Sometimes flaking is done from different directions on different edges, or two to three directions of trimming on one edge, and there are at least two to three working edges on each tool. In this particular industry I think that the cores were for the production of thick flakes. Flake tools took first place in production and use in Guanyindong.

At Guanyindong the average breadths and lengths of core tools and of flake tools are similar; this results from the shape of the chert nodule. There are 28 pieces (76%) retaining cortex, four of them on the platforms (Fig. 3). Platform preparation seems characteristic in the technology,

and is revealed by flake scars (average 3) on the platform (21 specimens) that were trimmed before the flake was taken off the core. Replication work did not lead me to discover any particular patterning of flake removal from the prepared platform, nor how the preparation changed the angle of the platform. I usually prepared my platform on the chert nodule as the beginning step in starting the knapping process.

The natural edges of the chert flake are very sharp, but thin. If these natural edges were used without retouch, they would soon be blunted. The value of the chert nodule (perhaps because it came from some distance away), or the lengthened edge life were obviously taken into consideration by the Guanyindong population. They retouched the edges steeply, following the natural flake shapes. Hence, the shapes of the Guanyindong tools are not regular: there are 37 specimens in the study, divided into 15 types.

(4) The Bhimbetka Assemblage: Quartzite and Sandstone

The Bhimbetka stone tool assemblage includes two kinds of raw material: flintknappers in the early period (Ia) preferred to make core tools of quartzite river cobbles, and of somewhat rounded and rolled sandstones that were weathered blocks. Flintknappers in the later period (Ib) were less opportunistic and they most certainly quarried raw materials from sandstone outcroppings, either nearby or some distance away. There is a 60 cm. sterile layer between

Ia and Ib. The quartzite cobbles, which do not appear later, must have come from the nearest stream at that time. I could not find any sample of quartzite cobbles for a geological thin section examination.

Thin section analysis for the Bhimbetka site was conducted only on the sandstone. This rock is tightly cemented, uniform quartz sandstone with overgrown quartz cement: tough, strong, and uniform. Because the results of the thin section analysis demonstrate that the sandstone materials quarried from the Bhimbetka hill are very good for tool making, the question is why did the flintknappers of Ia not use them for tool making? I think that the cobbles and weathered blocks represent an expedient choice by the Ia group, because it was easier than quarrying material. What caused the Ib group to forego this expediency? There are at least two possible explanations for not choosing the same raw materials as the Ia group. First, the quartzite cobbles may have been covered over, or nearly gone. There are a number of natural depositional forces that could have buried this raw material resource, hiding it from the later group of knappers. The second possibility is that the tool makers, in developing their technology, found the quarried raw materials made better tools.

Of the 9 core tools in the study, 7 (78%) are found in Ia, and only 2 (22%) are in Ib. The average dimensions of the core tools from Ia are 127x92x60 mm.; those Ib layer are

135x98x57 mm. (Fig 5). There is not much difference in the average sizes of tools from these two layers. In general, the quarried sandstone made tools (Ib) that were thinner. Of the 4 flake tools, 3 were found in Ib, and only 1 was from Ia. The average dimensions of the flake tools from Ib are 146x93x35 mm.; the flake tool from Ia measures 72x40x24 mm. (Fig. 5), and hence is much smaller than those from the top layer (Ib).

If representative, these numbers indicate that core tools were preferred by the Ia group, and that they used cobbles or weathered blocks, whatever was handy, to make these core tools. Trimmed flakes were a by-product of core production. The Ib group quarried chunks and large flakes of raw material from the sandstone outcrop. Then from these raw shapes flake tools were the first choice of their production. The study shows that there is no positive correlation between quartzite raw material and the unifacial technique, but there is a connection between the unifacial technique and the Ia knappers, because about 75% of the unifacially produced tools (both quartzite and sandstone) are from the Ia layer.

The raw materials used by the Ia group were flat cobbles or rolled weathered blocks, on which one can get a sharp edge more quickly by unifacial flaking than by bifacial flaking. In spite of the fact that there are many differences between these two layers (e.g., expediently

chosen cobbles and weathered blocks in Ia vs. quarried sandstone outcroppings in Ib; unifacial core tools predominate in Ia vs. bifacial flake tools in Ib), there are no transitional forms in typology between the two groups. Hence, I do nct believe there was an evolutionary sequence from "pebble tools" to "handaxes" at Bhimbetka.

(5) The Hunsgi Limestone Assemblage

The raw material used at Hunsgi is mainly limestone. Thin section analysis of this material suggests that it is a very fine-grained and even rock, with excellent breaking potential. The Hunsgi limestone is 100% calcite. Calcite is very soft, therefore it is not very good at retaining an edge. Calcite also has a strongly developed cleavage that allows it to break more readily than quartz so calcite tools would break more easily than quartz tools. The limestone resources for these ancient flintknappers are mainly the limestone plateau that is 2-3 km. north of the site. The thickness of the limestone slabs gathered from the plateau suggests that the limestone usually breaks down in layers about 10-30 cm. thick, often between 10-20 cm. The dimensions of the limestone slabs are 234x165x75 mm., the ratio of these dimensions to those of the core tools (141x87x59 mm.) is 4:1 (Fig. 2). Combining this fact with the average number of flake scars on the core tools (19) shows that a large quantity of flakes were taken off each core. My replication work also demonstrates this. Because

the limestone is brittle, it is easy to strike off pieces of debitage in the process of producing large flakes. The average dimensions of the flake tools are 116x84x37 mm., quite close to the sizes of the core tools (Fig. 5). Most of the flakes that were trimmed by the roughing-out step are thicker, with a flat, wide platform and natural sharp edges all around. This phenomenon together with the replication work provides a test and verification of the suggestion that the quarried limestone used by the Hunsgi flintknappers was basically slab or block shaped. Because the limestone slabs were more or less flat, bifacial trimming from the corner of one extreme end to the other end would produce a thick platform with a sharp natural distal edge, and would leave a core with a sharp edge but one that is very thick centrally. When either lateral edge of the flake is very thick, unifacial trimming would be the best way to produce sharp edges (89% of flake tools are unifacially trimmed). All of the core tools in the study (100%) were trimmed bifacially. This available raw material (limestone slabs) determined the technique and the main types of the stone assemblage in Hunsgi.

Hammerstones

The hammerstones I used in the replication work were chosen from whatever was available, so a variety of attributes were observed and measured. Hammerstones should

be rounded or sub-rounded with at least one flat surface. The size of the hammerstone can vary: if I use a large one, it cannot be larger than my hand; if I use a small one, it cannot be so small as to allow my fingers to wrap all the way around the stone. Choosing a hammerstone of appropriate weight to the average weight of the raw material is the most difficult problem. My experimentation suggests that the weight of the hammerstone should be roughly half the weight of the average raw material, but there are exceptions. At Hunsgi, the only hammerstones available were granite cobbles. This was also the case during the prehistoric period; due to its structure, limestone cannot be used as a hammerstone. Granite has an interlocking texture (in which particles with irregular boundaries interlock by mutual penetration). Although the size is small the weight is heavy. The hammerstone I used was half the average dimensions of the limestone in size, but was two times the average weight of the limestone slabs I used as the raw material. The granite hammerstone is very strong, and easy to hold, but requires a a high level of sensitivity in the degree of force used with each blow. This skill requires a great deal of practice, and even so, the heavy hammerstone usually produces more debitage than usual (the quantity of debitage is more than half the total number of the artifacts in the Hunsgi stone tool assemblage).

There is no problem finding good hammerstones when the raw materials come from the river bed or from the ancient gravel layers. I had many choices to pick from for hammerstones, either in the same rock type as the raw materials or in a different type. In some sites, such as Guanyindong, there are no other rounded stones, so chert nodules had to be used for hammerstones as well as for raw material. In practice, the hammerstone can be broken in half, or flaked into a core. This may be the reason why there were no hammerstones found in the collections from Guanyindong: most hammerstones were eventually broken up by use. A good hammerstone must have been a valuable tool of production, and flintknappers probably took their hammerstones with them when they moved.

All the stone tools replicated at the eight archaeological sites were produced with hard hammer, direct percussion, using my left thigh to support the stone. At some sites, I used only one size of hammerstone, or only one hammerstone. For other sites, I had to use three different sizes of hammerstones to replicate the tools. This was usually because the stone tools required a detailed retouching of the edges, and when the proportion of reduction is large, there is a great difference between the size of the original raw material and the sizes of the final tools. I also practiced the bi-polar technique and block-on-block technique on each stone tool assemblage, but I am

not very confident about these two techniques. I think they should be employed only when the size and the shape of the raw material is quite abnormal or awkward. When a stone is too small to hold in the hand, for example, bi-polar technique can help break it into pieces. When the entire circumference of the rock is equally thick and broad, the block-on-block technique can help to break the rock into large flakes. In general, however, I found a hard stonehammer to be not only the most practical and efficient, but also the most widely distributed technique used to make the tools found in the Lower Paleolithic stone tool assemblages.

4. Conclusion

The first, and by now the most obvious, issue that has been discussed here is that of the relationships between the type, shape, and size of available raw material, the technologies employed, and the range of possible artifact forms. My replication experiments demonstrate the strength of this relationship, and the mineralogically revealing thin sections provide further corroborative evidence.

It is always perilous to generalize from one example to an entire population, and it is not much less perilous to generalize from these eight sites to the whole of the Lower Paleolithic in southern and eastern Asia. The results of my study, however, should serve as a warning against any simple

comparisons between early Asian stone tool assemblages and those of the rest of the Old World. There can be no meaningful comparison concerning the range of variability or diversity among tool assemblages unless the availability of raw material as well as the relevant mineralogically - determined knapping characteristics of that raw material are analyzed and taken into account.

It follows that the concept of "mutually exclusive tool traditions," defined by two standard tool kit typologies, must be replaced by a more balanced appreciation of the evidence. There is now, in fact, a large enough collection of instances where "pebble tools" are found in the areas traditionally assumed to be exclusively "hand-axe" zones, and where "hand-axes" have been recovered from so-called "chopper-chopping" tool zones, to justify abandonment of the concept of exclusive tool traditions. Moreover, as I have shown above, the classification system on which such "exclusive" schemes were based can be misleading.

Besides the potential and limitations inherent in the available lithic raw material, other factors can and should be considered as explanations for diversity in tool traditions. Some of these factors have been discussed by Africanist prehistorians. In African Middle Pleistocene industries there appear to be two important components of variability operating within the same environment upon the same raw material. These are variation in percentage

frequency of major artifact classes, and differences in the shapes and degree of refinement of individual stone tools. There have been three theories put forward to explain these variations. The first is suggested by M. D. Leakey (1975), who thinks that the variations result from two coexsisting but non-interbreeding hominid populations. The second theory has been developed by J. D. Clark (1959), Jones (1979), and Kleindienst (1961). These archaeologists suggest that different kinds of tools were produced for different tasks or activities were carried out in different places. The third and last interpretation of variation found in African tool industries is that of the late G. Isaac (1972). Isaac thinks that tool kits with many different characteristics may have been equally effective, so that tool-making habits could be the result of temporary local fashions or the result of random changes and varying levels of skill.

The above explanations of variabilty should all be considered in a thorough study of a tool industry, but they are secondary to the most basic limitation of Middle Pleistocene stone tool industries, namely, the nature of the available raw material. I find that archaeologists often think it is simple to use direct percussion with large cobbles or boulders to make a tool. But, they are wrong. It is not only a question of strength to break a stone and produce a tool, it requires considerable skill to read the

nature of the raw material and use just enough strength at the right point on the stone to produce the desired result. There is room for variation based on skill and need, but this variation is always ultimately limited by the nature of the raw material.

Once a more balanced appreciation of the range of subsistence behavior and its accompanying tool requirements is achieved, it is possible to examine and to refute the notion of a Southeast Asian Lower Paleolithic technological or cultural "retardation." Local circumstances, therefore, contribute to a wide range of variation in the technological patterns we expect to find. It seems obvious that such circumstances would also affect both the behavioral and adaptive patterns of ancient hominids. It is by this balance of subsistence behavior and its accompanying tool requirements that we should consider the cognitive ability of the Lower Paleolithic hominids of Southeast Asia rather than the narrow typological attributes of stone tools.

Despite suggestions by Wynn (1979) there is no proven correlation between lithic technology and cognitive ability. Yet, even if there were such a correlation, manufacturing stone tools from a brittle and junctured quartzite or a planar structured limestone is every bit as cognitively challenging as producing a symmetrical straight edge from a uniformly structured chert (Toth, 1985). There are also examples as noted in the introduction here, where

technological results do not follow hypothesized cognitive thresholds, namely where *Homo sapiens sapiens* populations produced and used "chopper-chopping" type tools. Nor does any consideration of cognitive ability based on lithic technology take into account the non-surviving non-lithic technology. As regards Southeast Asia, one can hypothesize subsistence strategies that do not require stone tools or that employ relatively perishable or unmodified material such as bamboo, bone, wood, horn, or shell.

Finally I think my replicative work has demonstrated that the potential and limitations inherent in available raw material are primary determining factors in Lower Paleolithic technology, that crude tools do not necessarily mean crude minds or limited cognitive abilities, and that primitive-looking tools are not necessarily truly primitive either in design or in execution. In fact, given the recalcitrant nature of the raw material at the study sites, we should be highly appreciative of the level of technological skill demonstrated there by strong, resourceful, and successful human groups.

Appendix A

Geological Thin Section Analysis of the Lithic Raw Materals

Robert Osborn
Department of Earth and Planetary Sciences
Washington University, St. Louis

I asked Osborn to conduct thin section tests on the raw material that I used to replicate the 8 stone tool assemblages that constitute this study. He graciously accepted this task, and this project took almost one year. In total 17 rocks were tested by thin section analysis. These thin sections were all taken from my replication tools (I took 60 replication tools back from my fieldwork). Sample choice is first based on the hand-sample. An experienced expert can identify many samples by eye and hand. Because Mr. Osborn was able to identify a number of the samples by inspection it was not necessary to conduct further thin section analysis of them. Hence, for some of the sites 3 samples were tested, for others only one was tested.

For those that required further enquiry, the thin section test provides information on the scientific type and name, the origin, mineralogical make-up and structure, and, most important for the present study the structural characteristics of each rock and how these structural characteristics enhance or degrade the tool-making potential of the stone. This result provides an objective test of the findings provided by my replication work, and further explains why raw material is a important factor for stone tool production.

Site: Lantian, China

Rock Type: Quartzite (metamorphic)

Rock Origin: Formed by a recrystallization of sandstone by either regional or thermal metamorphism.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	>90%	bimodal large .5-1mm small .05-.1mm	elongate grains
	Mica	~5%	laths .03x.1mm on average	roughly aligned in parallel bands

Rock Fabric: Gneissic with incipient schistosity.

Grain Shape: Quartz-elongate ovoids. Mica-laths and plates.

Grain Boundaries: Quartz is strongly sutured.

Uniformity: Grain size and mineralogy patchy.

Characteristics that might enhance or degrade tool making potential for this rock:

Tough because of abundant quartz; mica imparts a planar weakness which will facilitate breaking into flat pieces if fabric is not too strongly developed in which case the rock will be quite weak. A small change in the percent of mica will greatly affect breakability in this sort of rock.

Site: Lantian, China

Rock Type: Quartzite impure (metamorphic)

Rock Origin: Probably formed by a recrystallization of sandstone by either regional or thermal metamorphism.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comment
	Quartz	70%	.2-.5mm	
	Muscovite	5%	.05-.1mm	
	Feldspar	15%	.5-2mm	altered

Rock Fabric: Incipient gneissic texture.

Grain Shape: Elongate and irregular.

Grain Boundaries: Interlocked

Uniformity: Domains of fairly uniform quartz grains separated by mica domains. Sporadic feldspar grains.

Characteristics that might enhance or degrade tool making potential for this rock:

Strong interlocking fabric of quartz but may be difficult to shape precisely because of poorly developed mica foliation(s), (layers). May have been very silicic igneous rock (at least 65% silica, or fieldspar bearing quartose sandstone).

Site: Lantian, China

Rock Type: Metamorphosed Granite

Rock Origin: Probably granite. Crystallized from a magma at some depth beneath earth's surface, later metamorposed.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Potassium Feldspar	30-40%	.6-2mm	mostly microline (Potassium Feldspar)
	Quartz	30%	.3-2m	undulating extinction
	Feldspar (perhaps altered plagioclase-feldspar)	20-30%	.3-2mm	badly altered
	Mica	5%	.1-.5mm	badly altered, small grains

Rock Fabric: Igneous, mosaic, equant with slight foliation.

Grain Shape: Subhedral (individual mineral crystals that are partly faced or incompletely bounded by their own crystal faces and partly bounded by surfaces formed against pre-existing crystals), equant crystals.

Grain Boundaries: Crystal boundaries, quartz grains have typical sutured metamorphic contacts.

Uniformity: Uniform on scale >1cm.

Characteristics that might enhance or degrade tool making potential for this rock:

Interlocking texture would make a tough rock but large feldspars with cleavage provide planes of weakness for deflecting fractures, probably resulting in a rough break surface. Fine detailed breaking would probably not be possible, but it may make a good hammerstone.

Site: Lantian, China

Rock Type: Mineral vein-variety quartz

Rock Origin: Hydrothermal precipitation

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	~100%	>.5mm	probably one or two crystals broken into domains by later forces

Rock Fabric: Large interlocked crystals broken by intensive fracture set

Grain Size: Large

Grain Shape: Angular

Grain Boundaries: Crystal boundaries

Uniformity: All same mineral, many fractures

Characteristics that might enhance or degrade tool making potential for this rock:

Pure quartz is tough and strong, but fractures should make breaking unpredictable.

Site: Liangshan, China

Rock Type: Quartzite (metamorphic)

Rock Origin: Probably formed by a recrystallization of sandstone by either regional or hydrothermal metamorphism.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	75-80%	.3-3mm	
	Opaque blades	15-20%	.02w x .3mm long	perhaps graphite

Rock Fabric: Intergrown crystals.

Grain Shape: Planar boundaries, irregular equant quartz tabular or acicular opaque.

Grain Boundaries: Extra large boundaries, straight and angular.

Uniformity: Variable

Characteristics that might enhance or degrade tool making potential for this rock:

Coarse grained. Plane crystal boundaries might provide too large an amount of oriented defects to allow consistent workability. Interlocking tough fabric.

Site: Liangshan, China

Rock Type: Hornfels. Fine grained metamorphic rock without planar fabric, i.e.: no foliation. Probably was a siltstone recrystallized by contact metamorphism.

Rock Origin: Heavily recrystallized, probably by heat from a nearby granite intrusion. Sedimentary texture obscure.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Epidote/ Chabazite yellow acicular	40-50%	.1-.25mm	radiating stellar, acicular clusters
	Quartz	40-50%	.01-.05mm	blocky, planar average crystal boundaries

Rock Fabric: Interlocking, intergrown crystal boundaries.

Grain Shape: Acicular epidote and blocky quartz.

Grain Boundaries: Planar crystal boundaries.

Uniformity: Fairly uniform on scale of mm.

Characteristics that might enhance or degrade tool making potential for this rock:

Enough quartz to impart toughness. Radiating rosettes might, depending on mineral, provide cohesiveness or weakness.

Site: Shilongtou, China

Rock Type: Quartzite (metamorphic)

Rock Origin: Detrital deposition, probably sandstone, which has been recrystallized by either a regional or thermal metamorphism.

Rock Characteristics:

Mineralogy:

Mineral	Volume%	Size	Comments
Quartz	95%	.3-.8mm	
Chert grains	2-3%	.2-.5mm	

Rock Fabric: Cement: syntaxial overgrowths on quartz.

Grain Size: Average, .5mm

Grain Shape: Rounded to subrounded

Grain Boundaries: Overgrown, sutured, many triple junctions.

Uniformity: Very uniform

Characteristics that might enhance or degrade tool making potential for this rock:

Clean quartz sandstone heavily cemented with quartz. Should be a very uniform and strong rock.

Site: Shilongtou, China

Rock Type: Quartzite (perhaps metamorphic)

Rock Origin: Detrital sand accumulation. Strongly cemented with quartz growth on sand grains in optical continuity with grains themselves. May have grown either during deep burial or metamorphosis.

Rock Characteristics:

Mineralogy:

Mineral	Volume%	Size	Comments
Quartz	90%+	.1-.15mm	undualtory extinction
Chert fragments	1-5%	.1-.2mm	polycrystalline
Rock fragments	1-2%		

Rock Fabric: Quartz cement, syntactic overgrowth on grains.

Grain Size: .1-.2mm

Grain Shape: Subangular

Grain Boundaries: Linear, slightly embayed, tight (quartz overgrowths).

Uniformity: Grains are on average .1-.2mm, sorting good.

Characteristics that might enhance or degrade tool making potential for this rock:

Moderately to poorly sorted quartzose sandstone. Strongly cemented by syntaxial quartz overgrowth on sand grains. Apparently unmetamorphosed. While this is a strong rock it is doubtful that it will be firm enough in texture to work to fine detail.

Site: Guanyindong, China

Rock Type: Chert

Rock Origin: Chert with pyrite/magnetite, or silicified rock with magnetite or pyrite.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	80%	.01-.015mm	interlocked grains
	Hematite (after pyrite or magnatite	20%	~.05mm	all altered to hematite and many are only rims

Rock Fabric: Uniform

Grain Size: Very fine grained.

Grain Shape: Equant

Grain Boundaries: Interlocked

Uniformity: Very uniform

Characteristics that might enhance or degrade tool making potential for this rock:

Tough fine-grained rock. Pyrite/hematite impart irregularities that otherwise might not be present. Fine (detailed) workability might be affected. Hematite gives red and reddish yellow color.

Site: Guanyindong, China

Rock Type: Chert

Rock Origin: Sedimentary, probably diagenetic replacement of limestone.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	100%	.005-.03mm	salt and pepper grain size and distribution

Rock Fabric: Contains perhaps a dozen ovoid domains .1-.5mm across that look like open space fillings, perhaps ostracodes or similar fossil in original sediment.

Grain Size: Very fine

Grain Shape: Equant-irregular

Grain Boundaries: Interlocking

Uniformity: Very uniform

Characteristics that might enhance or degrade tool making potential for this rock:

Uniform chert should be good tool making material, contains practically no irregularities.

Site: Bose, China

Rock Type: Silicified limestone

Rock Origin: Chemical replacement of preexisting rock by fine-grained silica. Ghost shapes (perhaps fossil fragments?) visible in plane-polarized light.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	>95%	.01-.04mm	very sutured and intergrown
	Black patches and holes	~5%	.1-.2mm	have square ghost shapes as though they may have been pyrite cubes. Also red in intense light-possibly hematite.

Rock Fabric: Uniform fine grained with occasional ragged holes.

Grain Shape: Equant

Grain Boundaries: Sutured

Uniformity: Very uniform except for irregular holes.

Characteristics that might enhance or degrade tool making potential for this rock:

Nice uniform strong rock if the holes (corroded pyrite) do not impart unpredictable weakness planes.

Site: Bose, China

Rock Type: Silicified limestone

Rock Origin: Unclear in thin section. Does not show any clearly recognizable original rock characteristics, thus must be alteration product or metamorphic, perhaps hydrothermal alteration of limestone.

Rock Characteristics:

Mineralogy:

Mineral	Volume%	Size	Comments
highly birefringent	10-20%	.01-.02mm	forms semi-aligned fabric in rock
dark opaque	>20%	.005-.01mm	equant
green, possibly epidote	20%	.005-.01mm	equant
Quartz	40-50%		fine grains

Rock Fabric: Cement: N/A

Grain Size: Very fine

Grain Shape: Equant to elongate

Grain Boundaries: Fine

Uniformity: Uniformly very fine grained <.01mm

Characteristics that might enhance or degrade tool making potential for this rock:

Very fine grained, nondescript rock in thin section. Light, high birefringent mineral has rod-like shape and is aligned in fabric but it may not establish plane of weakness. Rock may be silicified and/or metamorphosed limestone.

Site: Bose, China

Rock Type: Silicified limestone

Rock Origin: Probably limestone replaced by quartz hydrothermally. Ghosts of former grains that might have been fossils can be seen. The rock also might be a chert.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	80+%	variable average <.02mm	blotchy irregular texture
	Opaque specks	10-20%	0-.02mm	cubic, may be pyrite

Rock Fabric: Mosaic, fine grained, interlocking.

Grain Size: Very small

Grain Shape: Equant

Grain Boundaries: Quartz interlocked

Uniformity:

Characteristics that might enhance or degrade tool making potential for this rock:

Fine-grained quartz-rich (tough) rock. Has irregular texture and impurities that will disturb uniformity and, thus, breakability. Should hold an edge if shaping is possible.

Site: Bhimbetka, India

Rock Type: Sandstone

Rock Origin: Detrital deposition

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Quartz	>95%	.1-.6mm	undulating extinction
	rock fragments chert	1-2%	.1-.5mm	
	metamorphosed rock fragments	1%	.2-.4mm	polycrystaline quartz sutured

Rock Fabric: Cement: abundant quartz overgrowths, minor CaCo3, fine-grained cement.

Grain Size: Variable, few large, many in .1-.2mm range.

Grain Shape: Subangular to subround, some well rounded.

Grain Boundaries: Planar, some indenting and triple junctions clean.

Uniformity: Poor to fair sorting.

Characteristics that might enhance or degrade tool making potential for this rock:

Tightly cemented uniform quartz sandstone with syntaxially overgrown quartz cement. Tough, strong and uniform.

Site: Bhimbetka, India

Rock Type: Sandstone

Rock Origin: Detrital sedimentation, perhaps metamorphosed

Rock Characteristics:

Mineralogy:

Mineral	Volume%	Size	Comments
Quartz, large	10-20%	.6-.8mm	undulating extinction
Quartz, small	70-80%	.2-.3mm	
Chert grains and rock fragments	1-3%	.2-.4mm	
Opaque oxides	1-2%	.1-.2mm	

Rock Fabric: Cement: Quartz outgrowths completely fill intergranular space.

Grain Shape: Original subangular to subround

Grain Boundaries: Triple junctions, planar, heavily modified. No pore space , heavily sutured and embayed.

Uniformity: Sorting-bimodal, reasonably good within categories.

Characteristics that might enhance or degrade tool making potential for this rock:

Extremely strong and uniform rock composed of quartz grains cemented by syntaxially overgrown quartz. Many examples of pressure solution, sutured boundaries and interpenetrations. Almost all pore space gone. Quartz all strained, could be metamorphic.

Site: Durkadi, India

Rock Type: Quartzite (sedimentary, finely laminated sandstone)

Rock Origin: Detrital sandstone, contains grains which very greatly in size and rounding. This probably indicates a relatively short transport history.

Rock Characteristics:

Mineralogy:

Mineral	Volume%	Size	Comments
Quartz, large and small bands	80+%	.05-.2mm	largest are well rounded
Sericite	2-5%	.05-.2mm	
Opaque oxides	2-5%	.05-.2mm	irregular
Hematite	1-2%	.05-.005mm	small translucent red xls

Rock Fabric: Cement: quartz, sericite, clays moderate to strongly cemented

Grain Size: .01-2mm

Grain Shape: Well rounded to very angular

Grain Boundaries: Distinct surrounded by cement

Uniformity: Laminations formed by grain size variation. Finer grained laminae contain more opaque minerals.

Characteristics that might enhance or degrade tool making potential for this rock:

Obvious textural layering should impart preferred parting direction. Multiple cements and variable grain size should make this rock fairly easy to break but not particularly wear resistant compared to purer quartzite.

Site: Hunsgi, India

Rock Type: Limestone (sedimentary limestone)

Rock Origin: Limestone composed of fine-grained carbonate mud is from marine environment.

Rock Characteristics:

Mineralogy:	Mineral	Volume%	Size	Comments
	Calcite	100%	^.01mm	very uniform

Rock Fabric: Uniform

Grain Size: Very fine

Grain Shape: Calcite, blocky

Grain Boundaries: Crystal boundaries

Uniformity: Very uniform and even

Characteristics that might enhance or degrade tool making potential for this rock:

Very fine-grained and even rock, excellent breaking potential. Calcite is very soft compared to steel, therefore not very good for edge retention. Calcite also has a stongly developed cleavage which allows it to break easier than quartz, so tools would break easier.

Appendix B

Glossary of Terms Used To Describe Stone Tools

Alternate. Retouch that is worked along part or all of both edges of a piece, starting from the dorsal surface on one edge and from the ventral surface on the other edge (Tixier, 1974).

Alternating. This is a term introduced by Bordes (1961:29). Alternating describes retouch that starts alternately from one surface then from the other on the same edge of a flake, blade, or bladelet (Tixier, 1974).

Angle of Platform. The angle formed between the butt and the ventral surface.

Anvil. Block of more or less hard rock placed on the ground, or in any case immobile. It represents an aid for tool-making, is often referred to as a method: "block-on-block" technique.

Assemblage. All artifacts (including debitage, etc.) found in a given layer at a site (Bordes 1972:185).

Bifacial. Bifacial retouch is retouch worked on both surfaces of an object, covering each surface partially or totally (Tixier, 1974).

Bipolar Technique. Refers to the method of flaking bipolar flakes from cores.

Breadth. This measurement was taken perpendicular to the length at the widest point (mm).

Chert (nodule). A dense aggregate of microcrystalline quartz. Chert often forms in limestone, perhaps in the diagenetic environment, and may replace fossil fragments, bedding etc., which can sometimes be recognized. Chert occurs as nodules, lenses, and beds in many sizes. It may vary from regular disks of small size to beds centimeters or even meters thick. Often occurs complexly intermixed with limestone (from Glossary of Geology, 1974).

Core. Block of raw material from which flakes are detached.

Cortex. The outer rind; natural, unaltered surface of a stone, whatever its expression.

Debitage. The intentional action of breaking a block of raw material (hard rock) in order to use the products (flakes,

blades, bladelets) as they are, or to convert these products into tools by retouch. Debitage also comprises the results of this action (Tixier, 1974:14).

Direct Percussion. With a stone in each hand, using one to strike the other to fracture one in order to produce a useful sharp edge.

Dorsal surface. It can be partly or totally a natural surface. Usually, however, the dorsal surface has traces of previous removals (flake scars) bounded by ridges (Tixier, 1974).

Edge Damage. Alteration of edge by use, natural causes, and /or post-depositional forces. The majority of tools included in this study showed some edge damage. Because I did not undertake any microscopic analysis of this damage, however, I cannot be sure of the origins or causes of the damage observed. Therefore, only the presence or absence of edge damage was recorded.

Flake. Fragment of hard rock intentionally detached from a block of raw material.

Granite. A rock formed at considerable depth (>1 Km or so - subject to interpretation) by crystallization of magma. A

plutonic rock in which quartz constitutes 10 to 50 percent of the felsic components and in which the alkali feldspar/total feldspar ratio is generally restricted to the range of 65 to 90 percent (from Glossary of Geology, 1974).

Gravel. An unconsolidated, natural accumulation of rounded rock fragments resulting from erosion, consisting predominantly of particles larger than sand (diameter greater than 2 mm., or 1/12 in.), such as boulders (diameter greater than 256 mm.), cobbles (64-256 in diameter), and pebbles (diameter less than 64 mm.) (from Glossary of Geology, 1974).

Hammerstone. `Natural hammer' (Bordes 1961:5) used by prehistoric stone workers for debitage or retouching hard rock. A hammer stone for my replication work is a cobble or block of stone.

Laterite. A highly weathered, red subsoil or material rich in secondary oxides of iron, aluminum, or both, nearly void of bases and primary silicates, and maybe containing large amounts of quartz and kaolinite. It develops in a tropical or forested, warm to temperate climate, and is a residual or end product of weathering (from Glossary of Geology, 1974).

Length. This measurement was taken at the longest dimension for core tools and flake tools. For flake tools, the tool is oriented with the striking platform as the proximal end, ventral face up. The length measurement was recorded from the proximal to the distal end (mm).

Levallois. A Levallois flake or Levallois blade is a `flake whose form is predetermined by special preparation of the core before the removal of this flake. This has nothing to do with the type of butt the flake has, which can be plain, faceted convex, or dihedral, depending on the nature of the core's striking platform' (Bordes 1961:14).

Limestone. A sedimentary rock consisting mainly (over 50% by weight) of calcium carbonate, primarily in the form of the mineral calcite. Limestones are formed by either organic or inorganic processes, and may be detrital, chemical, oolitic, or recrystallized. Many limestones are highly fossiliferous and obviously represent ancient shell banks or coral reefs. Fine-grained limestones (micrites or lithographic limestones) used as tools are probably accumulations of small crystals from algae (from Glossary of Geology, 1974).

Modification. The act of morphological alteration of a unit of lithic material by a human agent. A core is a modified

piece of stone, whereas a flake struck from the core is a distinct unmodified lithic unit until it is subsequently altered by human activity (Bradley, 1975:6).

Proximal end, Distal end, and Lateral edge. The proximal end is that which bears the butt and bulb; the other extremity is called the distal end. The lateral edges are the two side edges between the proximal and distal ends of the flake.

Quartz. Quartz is a crystalline silica oxide. Next to feldspar, quartz is the most commonly occurring mineral, occurring either in colored and transparent hexagonal crystals or in crystalline or crypto-crystalline masses. Quartz forms the major proportion of most sands and has a widespread distribution in igneous, metamorphic, and sedimentary rocks (from Glossary of Geology, 1974).

Quartzite (metamorphic). A granoblastic metamorphic rock consisting mainly of quartz and formed by recrystallization of sandstone or chert by either regional or thermal metamorphism. Granoblastic refers to a secondary texture, recrystallization caused by metamorphism (from Glossary of Geology, 1974).

Raw Materials. All lithic materials that were selected by the original flintknappers, or by me in my replication work, for the production of flaked stone tools.

Retouch. To retouch is to shape, sculpt, or transform a product of debitage into a tool, either by percussion (direct, indirect, on an anvil, etc) or by pressure flaking. Retouch is the trace left by this action (or by utilization) (Tixier, 1974).

Sandstone. A clastic sedimentary rock composed of rounded to angular fragments of sand size (in mm.), may be set in a fine-grained matrix, usually of silt or clays, and more or less firmly united by cementing material. Examples in this study are mainly composed of quartz grains, cemented with quartz with little if any matrix. Calcium carbonate and other minerals also occur as cement. If metamorphosed (heat and pressure applied), sandstone becomes quartzite or meta sandstone (from Glossary of Geology, 1974).

Sequence. Those techniques that are applied to the stone form an identifiable cultural pattern. This pattern is visible in the prehistoric record in the lithic remains at knapping locations (Flenniken 1985:131).

Silicified limestone. A limestone in which the CaCo3 has been chemically replaced by some form of silica (Quarts, chalcedony, opal) probably by hydrothermal fluids (hot spring) (Osborn personal communication, 1992).

Siltstone. Clastic sedimentary rock composed of silt sized particles (from Glossary of Geology, 1974).

Step. A change in a knapper's process orientation that may or may not involve a change of technique. When a knapper is striking flakes from a core, she has a flake production orientation; however, when she begins to modify one of these flakes, her process orientation changes. Each of these changes constitutes a step (Bradley, 1975:6).

Stone Tools. It is obvious that among the various pieces of worked stone, some pieces were tools, and others weapons or component parts of weapons. As is customary, we will use the term `tools' to refer to the ensemble of weapons and tools. One reason for doing this is for simplicity's sake, another is because in most cases we cannot prove whether a piece of worked stone was a weapon or tool (Tixier, 1974).

Striking Platform. `The part of a core upon which one strikes' (Bordes 1961:5) in order to detach a flake. A

striking platform can be a natural surface, or plain, or prepared.

Techniques. Each technology is composed of a number of particular techniques, which are specific methods by which flakes are removed from a stone to achieve a particular goal (Flenniken, 1985:131).

Technology. The sum total of flintknapping knowledge possessed by a group of knappers and demonstrable from the end-products of their knapping behavior. The technologies are defined by both technique and sequence. For example, if the same techniques were used at two sites, but the sequence in which those techniques were applied to the stone differs, then we are observing two different technologies (Flenniken, 1985:131).

Thickness. This measurement was taken at the thickest portion of the artifact (mm).

Unifacial. Unifacial retouch is retouch worked on one surface of an object, covering either surface partially or totally.

Ventral surface. It is the fracture plane formed by the shock wave of the striker inside the core, which separates

the flake from the core. On this flake face one can see the cone of percussion, not always pronounced but sometimes multiple, the bulb of percussion, and frequently below this the waves or ripples whose concavity is always turned toward the cone of percussion. These waves or ripples are traces of the direction of the shock wave, which allow one to orientate the flake even if the butt is missing. A well developed cone of percussion indicates the use of a hard striker. Sometimes a part of the bulb is removed by one or more small chips, leaving a feature called the bulbar scar on the bulb (Bordes 1961:5).

Weight. This attribute was recorded for all artifacts (gm).

Appendix C

Types of Stone Tools

Flake with single lateral unifacial edge [F1]

One lateral edge of the flake was trimmed unifacially.

Flake with double lateral unifacial edges [F2]

Both lateral edges of the flake were trimmed unifacially.

Flake with unifacial distal end perpendicular to double lateral edges [F3]

The distal end of the flake was trimmed unifacially and perpendicular to both lateral edges. Both lateral edges were made either unifacially or bifacially.

Flake with unifacial distal point [F4]

The distal end of the flake is the point, which was trimmed unifacially.

Flake with unifacial leaf-shaped distal end [F5]

The distal end of the flake is leaf-shaped and was trimmed unifacially.

Flake with unifacial leaf-shaped proximal and distal ends [F6]

The proximal and distal ends of the flake are leaf-shaped and were trimmed unifacially.

Flake with unifacial distal end [F7]

The distal end of the flake was trimmed unifacially.

Flake with unifacial proximal end [F8]

The proximal end of the flake was trimmed unifacially.

Flake with unifacial distal and proximal ends [F9]

The distal and proximal ends of the flake were trimmed unifacially.

Flake with all unifacial edges [F10]

The entire edge, or at least 95% of the circumference, of the flake was trimmed unifacially.

Flake with unifacial edges in other shapes [F11]

The edges of the flake were trimmed unifacially in other shapes.

Flake with single lateral bifacial edge [F12]

One lateral edge of the flake was trimmed bifacially.

Flake with double lateral bifacial edges [F13]

Both lateral edges of the flake were trimmed bifacially.

Flake with bifacial distal end perpendicular to double lateral edges [F14]

The distal end of the flake was trimmed bifacially and perpendicular to both lateral edges. Both lateral edges were trimmed either bifacially or unifacially.

Flake with bifacial distal point [F15]

The distal end of the flake is the point that was trimmed bifacially.

Flake with bifacial leaf-shaped distal end [F16]

The distal end of the flake is leaf-shaped and was trimmed bifacially.

Flake with bifacial leaf-shaped proximal and distal ends [F17]

The proximal and distal ends of the flake are leaf-shaped and were trimmed bifacially.

Flake with bifacial distal end [F18]

The distal end of the flake was trimmed bifacially.

Flake with bifacial proximal end [F19]

The proximal end of the flake was trimmed bifacially.

Flake with bifacial distal and proximal ends [F20]

The distal and proximal ends of the flake were trimmed bifacially.

Flake with all bifacial edges [F21]

The entire edge, or at least 95% of the circumference of the flake, was trimmed bifacially.

Flake with bifacial edges in other shapes [F22]

The edges of the flake were trimmed bifacially in other shapes.

Flake tool in other shapes [F23]

The flake was trimmed in different directions, and in irregular shapes.

Core with single unifacial edge [C1]

One edge of the core was trimmed unifacially.

Core with double unifacial edges [C2]

Two edges of the core were trimmed unifacially.

Core with one unifacial end perpendicular to both edges [C3]

One end of the core was trimmed unifacially and perpendicular to both edges. Both edges were made either unifacially or bifacially.

Core with one unifacial point [C4]

There is a point on the core tool, which was trimmed unifacially.

Core with one unifacial leaf-shaped end [C5]

One end of the core tool is leaf-shaped and was trimmed unifacially.

Core with two unifacial leaf-shaped ends [C6]

Two ends of the core tool are leaf-shaped and were trimmed unifacially.

Core with all unifacial edges [C7]

The entire edge, or at least 95% of the circumference of the core, was trimmed unifacially.

Core with unifacial edges in other shapes [C8]

The edges of the core were trimmed unifacially in other shapes.

Core with single bifacial edge [C9]

One edge of the core was trimmed bifacially.

Core with double bifacial edges [C10]

Two edges of the core were trimmed bifacially.

Core with one bifacial end perpendicular to both edges [C11]

One end of the core was trimmed bifacially and perpendicular to both edges. Both edges were made either bifacially or unifacially.

Core with one bifacial point [C12]

There is a point on the core tool that was trimmed bifacially.

Core with one bifacial leaf-shaped end [C13]

One end of the core tool is leaf-shaped and was trimmed bifacially.

Core with two bifacial leaf-shaped ends [C14]

Two ends of the core tool are leaf-shaped and were trimmed bifacially.

Core with all bifacial edges [C15]

The entire edge, or at least 95% of the circumference, of the core tool was trimmed bifacially.

Core with bifacial edges in other shape [C16]

The edges of the core were trimmed bifacially in other shapes.

Core tool in other shapes [C17]

The core was trimmed in different directions and in irregular shapes.

Unmodified flake [U1]

There is edge damage present on one or two edges of the flake, but it is not certain whether it has been altered by human activity.

Debitage flake [D1]

The waste flake or product of the intentional breaking of a block of raw material.

Debitage core [D2]

The waste core from the production of a flake tool, or the result of an aborted attempt to produce a tool.

Appendix D

Computer Coding Sheet

1. Sitename:

Lantian = LT
Liangshan = LS
Shilongtou = SLT
Guanyindong = GYD
Bose = BS
Bhimbetka = BA
Dukati = DI
Hunsgi =HI

2. Stone Tool Manufacture Process Key:

Flake with single lateral unifacial edge = F1
Flake with double lateral unifacial edge = F2
Flake with unifacial distal end perpendicular to double lateral edges = F3
Flake with unifacial distal point =F4
Flake with unifacial leaf-shaped distal end =F5
Flake with unifacial leaf-shaped proximal and distal ends =F6
Flake with unifacial distal end =F7
Flake with unifacial proximal end =F8
Flake with unifacial distal and proximal ends =F9
Flake with all unifacial edges = F10
Flake with unifacial edge in other shapes =F11
Flake with single lateral bifacial edge = F12
Flake with double lateral bifacial edges =F13
Flake with bifacial distal end perpendicular to double lateral edges =F14
Flake with bifacial distal point =F15
Flake with bifacial leaf-shaped distal end =F16
Flake with bifacial leaf-shaped proximal and distal ends =F17
Flake with bifacial distal end =F18
Flake with bifacial proximal end =F19
Flake with bifacial distal and proximal ends =F20
Flake with all bifacial edges =F21
Flake with bifacial edges in other shapes =F22
Flake tool in other shapes =F23

Core with single unifacial edge =C1
Core with double unifacial edges =C2
Core with unifacial distal end perpendicular to both edges =C3
Core with one unifacial pointed =C4
Core with one unifacial leaf-shaped end =C5
Core with two unifacial leaf-shaped ends =C6
Core with all unifacial edges =C7
Core with unifacial edge in other shapes =C8

Core with single bifacial edge =C9
Core with double bifacial edges =C10
Core with one bifacial end perpendicular to both edges = C11
Core with one bifacial point =C12
Core with one bifacial leaf-shaped end =C13
Core with two bifacial leaf-shaped ends =C14
Core with all bifacial edges =C15
Core with bifacial edges in other shapes =C16
Core tool in other shapes =C17

Unmodified flake =U1
Debitage flake =D1
Debitage core =D2

3. Field Artifact Information:

Catalogue number =1
Artifact type =2
Orientated length (mm) =3
Orientated breadth (mm) =4
Orientated thickness (mm) =5
Weight (grams) =6
Location of edge damage =7
Raw material =8
Platform thickness =9
Platform Breadth =10
Number of scars on platform =11
Number of dorsal scars =12
Number of ventral scars =13
Platform angle =14
Strike from ventral to dorsal =15
Strike from dorsal to ventral =16
Alternate =17
Alternating =18
Amount of cortex =19
Number of flake scars on the core =20

4. Raw Material:

Chert =01
Granite =02
Limestone =03
Quartz =04
Quartzite =05
Sandstone =06
Silicified limestone =07
Volcanic =08
Other =09

5. Number of Scars on Platform, and Dorsal Surface:

Cortex =0

Plain fracture =1
2 scars =2
3 scars =3
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VOLUME II

WASHINGTON UNIVERSITY

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EARLY PALEOLITHIC TECHNOLOGY IN CHINA AND INDIA

by
Jian Leng

A dissertation presented to the
Graduate School of Arts and Sciences
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

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Catalogue	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick	P. Breadth	M.S.P.	N.D.S.	N.V.S.	P. Angle	VTP	Div	On	A Cortex	N F. Scars
P3057	C1	208	128	78	3500	CSE	QI										2/1	5
P3017	C1	135	118	92	3200	CSE	QI										2/3	5
P3050	C1	152	113	62	2000	CDE	QI										1/5	6
P3058	C1	120	140	82	1500	CSE	QI										2/3	1
P3048	C1	210	113	111	1300	CSE,CV	QI										2/3	1
P3166	C1	119	112	41	1800	CSE,CV	QI										2/1	1
P3049	C1	98	57	65	300	CSL	QL										2/3	3
P3074	C1	82	79	35	100	CSF	QE										1/2	4
P3046	C1	180	172	114	2000	CSE	SI										3/4	2
P3051	C2	186	154	103	3000	CSE	QI										1/2	5
P3061	C3	145	147	110	2750	CAE	QI										[illegible]	8
P3070	C5	188	181	109	3000	CDE,CP	QI										1/2	6
P3065	C5	182	138	98	3100	CP	QI										2/3	3
P3075	C5	181	114	78	2000	CSE	QI										3/5	8
P3088	C5	130	102	48	1000	CSE	QI										3/4	7
P3105	C9	48	44	30	60	CSE	QZ										1/4	8
P3080	C9	74	95	36	600	CKE	QF										3/1	9
P3160	C18	162	94	68	1000	CDE	QI										1/1	12
P3071	F1	118	130	78	800	BKE	QI	22	41	8	1	none	88	VTD			[illegible]	
P3077	F2	133	130	48	500	BDE	QI	25	12	2	8	none	111	VTD			1/2	
P3407	F5	171	122	60	800	BDE	QI	18	121	2	1	none	110	VTD			[illegible]	
P3061	F14	82	81	34	100	BE	QB	12	92	0	3		129				1/6	
P3073	U1	112	76	24	200	BSE	QI	18	60	1	8	none	102				1/2	
P3076	U1	260	126	56	1700	BSE	QI	38	88	0	1	none	120				[illegible]	
P3055	U1	32	49	21	50	BSE	QZ	21	50	0	4	none	101				[illegible]	
P3056	U1	55	59	70	40	BSE	QZ	12	56	0	1	none	124				1/6	
P3052	B1	84	38	8	80		QB	8	15	0	2	none	91				[illegible]	
P3070	B2	40	41	12	800		QL										1/8	7

Table 1. Field artifact information from Lantian

Catalogue Number	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.B.P.	N.D.S.	N.V.S.	P. Angle	VID	BIV	OD	A.Cortex	N.F. Scars
15 Langshan P0103	C1	111	100	42	500	CSE	QE										1/6	4
15 Pingliang P0307	C1	122	136	60	1000	CSE	QE										3/4	3
15 Liangshan P0169	C1	85	70	53	100	CSE	QE										3/4	3
15 Liangshan P0300	C1	101	90	43	300	CSE	VC										1/3	5
15 Liangshan P0230	C1	110	70	60	1000	CSE	QE										0/0	2
15 Liangshan P0133	C1	88	40	43	100	CSE	QE										1/0	2
15 Langshan P0293	C1	208	90	81	2000	CPS	VC										4/3	4
17 Langshan P0302	C1	80	104	83	400	CPS	QE										2/3	3
15 Langshan P0301	C1	84	94	71	300	CPS	QE										4/3	3
15 Langshan P0203	C1	81	88	91	300	CPS	QE										3/4	4
15 Langshan P0292	C1	200	110	90	3300	CSE,CPS	QE										4/3	6
85 Liangshan P0207	C1	70	72	95	800	CSE,CPS	QE										4/3	2
15 Liangshan P0261	C1	112	95	52	500	CSE,CPS	VC										1/0	6
SPB Chitulin 01001	C1	200	96	73	1000	CP,CPS	QE										4/3	7
Chitulin 3	C1	250	109	72	2000	None	QE										1/6	10
Longgangai P0310	C2	140	74	87	800	CP	VC										1/0	8
42 Longgangai P0311	C2	113	82	62	500	CDE	VC										....	4
Liangshan 85.11	C2	85	79	43	800	CSE,CA	QE										3/7	6
15 Langshan P0302	C2	150	106	63	1000	CSE	VC										2/3	4
Chitulin 3	C5	170	119	90	2000	CP,CPS	VC										2/3	7
Longgangai P0314	C7	86	84	60	500	CA	QE										1/2	8
Liangshan 85.14	C7	123	108	40	600	CA	VC										1/2	6
85 Langshan P0303	C9	108	98	88	1000	CSE,CPS	QE									OD	2/3	5
85 Liangshan P0260	C9	100	80	66	1000	CE	QE										2/3	8
Longgangai P0217	C9	173	126	47	1000	CPS	VC										1/3	10
Longgangai P0221	C9	132	110	99	1000	CSE,CPS	VC										1/3	5
85 Langshan P0268	C9	135	142	81	2000	CSE,CPS	VC										2/3	6
85 Liangshan P0205	C9	98	95	70	500	CE	VC										4/2	7
85 Langshan P0221	C9	82	70	43	300	CSE,CPS	QE										1/2	8
Longgangai 10208	C9	68	48	30	80	CSE	QE										4/3	10
Longgangai P0224	C9	70	94	53	100	CSE,CPS	QE										1/2	8
Longgangai P0225	C9	98	63	47	500	CA	QE										4/3	8
85 Langshan P0259	C9	112	92	60	600	CSE,CPS	QE										2/3	8
Longgangai P0213	C9	108	100	67	600	CSE,CPS	QE										4/3	6
85 Langshan P0290	C9	100	100	82.5	800	CSE,CPS	QE										1/3	7
85 Liangshan P0285	C9	130	97	66	1000	CSE,CPS	QE										2/3	3
85 Liangshan P0284	C9	96	83	90	600	CSE,CPS	QE										3/4	3
85 Liangshan P0261	C9	70	70	40	100	CSE	QE										1/3	3
Longgangai P0222	C11	60	84	69	100	CA	VC										1/4	11
Longgangai P0313	C13	112	100	81	1300	CP,CPS	VC										1/4	6
SBP Chitulin 01003	C13	124	88	74	1000	CP,CPS	QE										0/3	8
85 Manshan 003	C13	131	96	84	300	CSE,CPS	VC										1/2	8
88 Mianyuan 004	C13	203	93	70	1100	CP	VC										1/2	13
Manlangyau 002	C13	138	100	60	800	CSE,CPS	VC										1/3	13
88 Mianyuan 014	C13	100	101	83	3000	CDE	QE										1/3	8
Langshan 0003	C13	100	88	83	1000	CSE,CPS	VC										1/8	10
Mianxian 002	C13	146	105	70	800	CP,CPS	QE										1/8	8
88 Mianyuan 005	C13	191	127	70	1100	CSE,CPS	QE										1/10	18
88 Mianhuangshe 001	C13	107	98	60	1000	CP	VC										1/4	13
Longgangai P0311	C13	100	96	81	1000	CSE,CPS	VC										1/3	13
82 Langshan P0210	C15	90	80	60	300	CA	QE										1/8	17
85 Langshan P0289	C15	97	78	44	300	CA	QE										1/6	13
82 Longgangai P0312	C15	127	103	60	1000	CA	QE										1/10	14
85 Langshan P0289	C17	70	70	70	800	CA,CE	VC										1/3	7
85 Langshan P0232	C17	73	82	80	500	CPS	QE										4/3	3
Longgangai P0208	C17	83	63	71	400	CE	QE										3/3	8
Longgangai P0220	C17	70	40	79	200	CA,CE	QE										2/3	3
Chitulin 1	C17	103	100	101	1300	CA,CE	QE										2/3	9
85 Liangshan P0180	C17	102	84	84	1100	CPD	QE										1/3	10
Liangshan 85 1	C17	80	50	84	100	CA	QE										1/2	5
Liangshan 85 3	C17	85	71	70	600	CA	QE										1/3	8
Liangshan 85.10	F5	148	78	83	600	FSL,FDE	VC	43	60.6	0	2	none	122	VTD			1/4	
85 Liangshan P0301	F5	110	80	34	300	FSL,FDE	VC	80	49	2	3	none	80	VTD			1/3	
85 Liangshan P0243	F7	40	20	8	25	FDL	QE	6	7	2	2	3	60		BTV		....	
85 Liangshan P0277	F8	79	47	18	40	FDL	VC	7	17	2	4	none	127	VTD			1/11	
85 Liangshan P0187	F8	130	122	89	1400	FDL	VC	40	60	0	3	none	122	VTD			1/2	
HD 008	F7	110	144	67	700	FDE	QE	63	110	0	0	3	125		BTV		1/3	
88 Liangshan P0270	F8	76	74	80	45	FDE	QE	10	23	0	4	none	83	VTD			1/4	
85 Langshan P0240	F9	131	89	34	800	FDP,FDL	QE	80	60	none	3	none	none	VTD			1/3	
Liangshan 85.8	F9	67	87	20	50	FDP	QE	10	60	2	0	none	127	VTD			1/3	
Liangshan 85.8	F9	30	84	80	30	FDE	VC	1	38	none	1	none	none	VTD			1/12	
Longgangai P0215	F12	72	100	45	800	FA	VC	33	50	0	2	7	80				1/4	
85 Liangshan P0201	F12	60	34	22	50	FSL	QE	8	10	0	3	3	90				1/6	
85 Liangshan P0274	F12	81	72	44	800	FSL,FPE	VC	20	40	2	3	0	140				1/1	
Liangshan 85 10	F13	84	70	32	200	FDL	VC	43	33	0	2	3	120				1/3	
85 Liangshan P0273	F13	76	70	22	100	FDE	QE	22	65	0	4	8	120				1/1	
85 Liangshan P0270	F14	60	84	34	800	FA	QE	22	65	0	0	4	125				1/3	
85 Liangshan P0208	F14	32	68	10	35	FA	QE	19	44	2	4	3	90				....	
Liangshan 85 7	F18	70	110	33	100	FDE	VC	28	103	2	3	3	110				1/4	
85 Liangshan P0210	F21	87	57	30	40	FA	QE	11	30	none	3	5	78				1/13	
85 Langshan P0265	U1	82	123	30	100	FDL,FDE	VC	24	84	0	1	none	127				1/2	
85 Langshan P0218	U1	90	73	18	70	FSL	QE	10	30	0	2	none	115				1/5	
85 Langshan P0217	U1	67	84	18	65	FDE	QE	1	10	0	0	none	0				1/2	
Longgangai P0229	U1	132	120	62	1100	FDE	QE	63	125	0	2	none	120				1/3	
Longgangai P0230	U1	136	104	60	1000	FA	QE	18	60	0	3	none	130				1/3	
Liangshan 85 5	U1	72	102	45	500	FDE	VC	15	83	0	0	none	90				1/2	
Liangshan 85 9	U1	25	42	12	10	FSL,FDE	QE	1	10	0	1	none	0				1/4	
85 Liangshan P0202	U1	50	52	10	35	FSL	QE	20	40	0	none	none	63				1/5	
Liangshan 85.3	U1	115	78	30	100	FSL,FDE	VC	38	40	0	none	none	110				1/3	
85 Langshan P0109	D2	62	60	45	100	CE	VC										0/11	3
Yangwangdong 008	D3	100	83	84	400	None	VC										1/2	6

Table 2. Field Artifact information from Liangshan

Catalogue	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	V.S.P.	N.D.S.	N.V.S.	P. Angle	VTD	DTV	OD	A.Cortex	N.F. Score
P3022	C1	88	100	34	500	CSE	QE										4/5	4
P3042	C1	66	74	24	55	CSE	CT										1/5	6
P3031	C2	44	64	38	60	CDE	QE									OD	1/3	6
P3036	C3	113	82	33	400	CA	BA										3/5	6
P3037	C5	127	92	50	1600	CDE,CP	QE										2/3	6
P3038	C5	104	118	74	1000	CDE,CE	QE									OD	1/2	10
P3021	C7	60	78	66	600	CK	QE										4/5	3
P3023	C7	70	84	73	800	CA	QE										1/2	7
P3025	C8	57	78	44	80	CSE	QE										1/3	7
P3024	C9	100	86	75	800	CSE,CE	QE										2/3	6
P3041	C9	74	54	20	55	CSE	QE										1/2	6
P3035	C9	66	79	41	80	CSE	QE										2/3	4
P3045	F1	62	60	10	50	FDE,FDL	QE	18	38	0	7	none	130	VTD			1/10	
P3030	F1	79	62	30	100	FDE,FDL	QE	24	37	2	1	none	120	VTD			1/8	
P3026	F1	63	54	10	48	FDE,FDL	QE	3	34	2	3	none	120	VTD			1/4	
P3034	F1	112	80	30	380	FSL	QE	38	60	0	2	none	130	VTD			1/10(P)	
P3033	F9	102	72	42	400	FA	QE	gone	gone	gone	6	1	gone	VTD			1/3	
P3032	F10	134	138	37	1500	FDE	QE	gone	gone	3	5	5	gone			OD	1/2	
P3044	F11	90	67	28	300	FA	QE	22	58	4	5	none	gone	VTD			1/3	
P3043	F11	61	87	60	100	FA	QE	10	31	5	0	8	gone		DTV		1/2	
P3027	F12	50	63	23	200	FDE	QE	26	38	2	4	0	132	VTD			1/7	
P3029	U1	56	38	17	35	FDL	BA	10	33	0	none	none	128				1/7(P)	
P3040	U1	64	42	10	35	FDL	QE	15	34	2	none	none	131				1/5	
P3028	U1	40	74	21	40	FDE	QE	10	42	0	1	none	122				1/2	

Table 3. Field artifact information from Shilongtou

Catalogue	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.S.P.	N.B.S.	N.V.S.	P. Angle	VTD	DTV	OD	A.Cortex	N.F. Scar
P4119	C8	81	107	100	1800	CPS	VC										1/3	9
P4116	C8	43	54	42	188	CPS	CT										1/5	6
P4117	C8	47	63	58	190	CPS	CT										1/10	11
P4114	C8	78	85	52	400	None	VC										1/2	6
P5255	C8	51	33	20	45	CSE	CT										1/12	5
P4110	C8	121	78	32	800	CA	CT										1/10	4
P5292	C11	38	40	24	38	CA	CT										1/7	1.
P4266	C13	80	60	30	184	CPS	CT										1/8	2.
P5268	C15	101	102	34	800	CA	CT										1/2	8
P4113	C17	48	43	38	100	CE	CT										1/2	4
P5271	F2	86	50	28	120	FSL	VC	24	30	3	8	11	100			OD	1/8	
P3057	F2	82	68	50	188	FDE	CT	10.5	46	1	6	3	127			OD	1/9	
P4281	F3	100	164	44	1000	FA	VC	32	188	4	7	1	125	VTD			1/10	
P5289	F3	48	70	18	80	FSL,FDP	CT	20	60	6	8	7	130			OD	##########	
P5303	F3	38	57	10	18	FDL,FDE	CT	0.9	14	0	18	4	125	VTD			1/16(P)	
P4274	F3	115	94	48	812	FDL,FDE	CT	40	20	1	18	0	118	VTD			1/6	
P4278	F3	78	94	34	218	FDL,FDE	CT	33	66	2	17	0	122	VTD			1/2	
P5366	F3	54	44	10	27	FDL,FDE	CT	9	24	0	none	9	120		DTV		1/14	
P5354	F3	45	30	20	32	FDL,FDE	CT	9	28	3	11	0	133	VTD			1/4	
P5299	F4	40	30	13	18	FDL,FP	CT	0.8	30	4	10	0	gone	VTD			##########	
P5277	F7	48	30	21	27	FDL,FDE	CT	1	20	2	7	8	98			OD	1/12	
P5258	F8	38	48	22	21	FA	CT	22	46	6	none	0	105	VTD			##########	
P5278	F10	58	50	32	65	FA	CT	30	58	4	8	0	125	VTD			1/16(P)	
P5312	F10	50	56	17	62	FA	CT	16	45	9	none	0	128		DTV		1/8	
P5311	F10	28	16	10	4	FA	CT	1.5	2	3	13	0	125	VTD			##########	
P3850	F10	80	113	22	300	FA	CT	23	79	3	28	4	gone			OD	##########	
P3051	F14	64	74	24	112	FDE	CT	24	42	4	6	8	130				1/16(P)	
P5367	F14	51	82	16	40	FA	CT	18	30	5	4	8	115				1/20(P)	
P3307	F15	80	48	23	71	FDL,FP	CT	23	43	3	13	9	115				1/7(P)	
P5397	F20	61	44	13	25	FDL,FDE	CT	10	22	4	0	4	120				##########	
P3953	U1	74	42	38	107	FDE	VC	33	34	0	3	4	130				1/2	
P5258	U1	63	34	18	24	FDL	CT	10	18	0	4	0	80				1/20	
P5260	U1	26	18	8	6	FDP	CT	9	18	4	none	0	118				##########	
P3359	U1	54	45	10	25	FDE,FSL	CT	10	20	2	2	0	125				##########	
P3916	U1	48	20	12	12	FSL	CT	11	38	2	1	0	130				1/2	
P5357	U1	49	22	11	9	FSL	CT	1.5	17	2	2	0	gone				##########	
P3941	U1	67	60	20	88	FSL	CT	10	60	2	2	0	125				1/5	

Table 4. Field artifact information from Guanyindong

Catalogue Number	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.S.P.	N.D.S.	N.V.S.	P. Angle	VTD	DTV	OD	A.Cortex	F Scars
Dongsen 3	C1	138	134	69	1000	CSE,CX	SE										1/2	8
Chaimu 5	C1	94	82	42	500	CX	SL										2/3	7
Tanhe 9	C1	135	101	60	1000	CSE	SL										3/5	5
Tanhe 5	C1	142	110	62	1000	CSE,CX	SL										3/4	6
Chaimu 8	C2	150	110	78	2000	CDE	SL										3/4	8
Dongsen 4	C2	180	141	63	1500	CDE	SE										4/5	6
Chaimu 9	C3	155	152	92	2000	CSE	SL										2/3	[illegible]
Chaimu 6	C3	108	84	50	800	CSE	SL										3/4	9
Chaimu 4	C5	165	130	73	1500	CP	SL										1/2	11
Shangsong 1	C5	151	124	80	2000	CX	QZ										2/3	7
Chaimu 7	C5	139	98	80	1200	CSE	SL										2/3	7
Tanhe 1	C5	146	122	54	1000	CDE,CX	SE										3/4	7
Tanhe 7	C5	150	124	72	1100	CDE	SL										3/5	15
Tanhe 8	C5	126	98	52	800	CX	SL										2/3	7
Tanhe 10	C5	202	160	100	2300	CP	SL										1/2	13
Lonsi 098	C5	172	121	58	1200	CX	SL										1/2	[illegible]
Dafa 59	C5	180	130	71	2000	CDE	SL										2/3	10
Lonsi 072	C5	208	132	65	1800	CP,CX	SL										2/3	6
Dongsen 2	C7	194	114	82	2000	CSE	SE										1/3	10
Dongsen 5	C7	128	92	80	1000	CA	SL										1/2	16
Dongsen 6	C7	168	120	72	1200	CA	SE										1/2	6
Tanhe 3	C7	140	124	78	1200	CSE	SL										1/2	13
Aozhao 03	C10	114	110	78	1000	CSE	SL										1/2	7
Tanhe 4	C13	150	150	80	1200	CP	SE										1/20	18
Datong 013	C13	182	113	78	1800	CSE	SL										1/5	8
Tangwucun 007	C13	183	120	73	1900	CSE	SL										1/12	21
Baisu 005	C13	215	128	70	2000	CDE	SL										1/3	13
Tangwucun 010	C13	179	97	74	2000	CP,CDE	SL										1/2	9
Domei 143	C13	163	144	65	1000	CP,CSE	SL										1/4	13
Dongsen 05	C13	130	104	74	500	CSE,CX	SL										1/2	9
Bose 10	C13	132	104	63	1000	CP	SL										1/3	9
Tanhe 6	C16	124	114	78	1000	CA	SE										1/3	10
Tanhe 11	C17	103	102	90	1000	CSE	SL										1/3	7
Baisu 51	F2	180	145	40	1000	FDE	SL	48	68	2	4	3	114	VTD			1/3	
Dongsen 1	F5	224	130	44	1000	FSL	SE	gone	gone	gone	8	4	gone			UU	1/3	
Nanposhan 1	F12	135	94	51	900	FSL	SL	31	88	0	6	4	110				1/4	
Chaimu 1	F16	194	112	60	1000	FDL	SE	60	79	0	8	7	132				1/5	
Liaofen 02	F16	230	170	74	2800	FDL	SE	74	143	0	8	8	105				1/4	
Dongsun 03	F16	183	137	78	1000	FDL	SL	40	95	2	8	12	114				1/10	
Nazhao 01	F16	150	124	64	1000	FDE	SL	84	120	0	5	7	98				1/5	
Chaimu 2	U1	140	90	45	900	FDL	SL	45	85	3	8	8	134				1/2	
Tanhe 2	U1	114	124	58	1000	FSL	SL	41	60	0	2	0	128				1/3	

Table 5. Field artifact information from Bose

Catalogue Number	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.S.P.	N.D.S.	N.V.S.	P. Angle	VTD	DTV	UD	A Cortex	N F	Scar
F-24 TR 11 Ia:3	C1	152	83	30	800	CSE	QE										9/10		8
F-24 TR 11 Ia:1	C9	118	90	32	1200	CSE	SE										1/2		7
F-24 TR 11 Ia:2	C9	90	60	56	300	CSE	QE										1/2		6
F-24 TR 11 Ia:4	C9	121	121	70	1000	CSE	QE										1/2		9
F-24 TR 11 Ia:7	C13	154	92	48	800	CA	SE										##########		24
F-24 TR 11 Ia:8	C13	152	92	48	700	CA	SE										##########		21
F-24 TR 11 Ib:10	C14	152	88	40	700	CA	SE										##########		21
F-24 TR 11 Ib:9	C15	110	112	74	1100	CA	QE										1/6		20
F-24 TR 11 Ia:6	C17	106	98	82	1100	CA	SE										##########		13
F-24 TR 11 Ib:11	F3	133	70	33	600	FDE	SE	10	78	8	3	11	120		DTV		##########		
F-24 TR 11 Ia:5	F5	72	40	24	120	FA	SE	10	33	2	10	3	135	VTD			##########		
F-24 TR 11 Ib:12	F13	145	100	30	600	FDL	SE	19	56	1	11	8	110				##########		
F-24 TR 11 Ib:13	F18	170	108	48	1900	FA	SE	48	92	1	13	10	140				##########		

Table 6. Field artifact information from Bhimbetka

Catalogue Number	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.B.P.	N.D.S.	N.V.S.	P. Angle	VTD	BTV	OD	A.Cortex	M.F. Scars
OLD 00010	C1	110	70	40	650	CSE	QE										2/3	3
DRK 00510	C3	108	130	54	1700	CA	QE										1/3	6
DRK 00388	C8	117	124	60	1300	CA	QE										3/5	3
DRK 00330	C9	149	102	64	1200	CSE	QE										2/3	4
DRK 00801	C9	214	134	80	3000	CSE	QE										1/2	6
DRK 1971 A	C9	172	117	60	1400	CSE	QE										1/2	5
DRK 00017	C9	88	86	28	300	CSE	QE										2/3	8
DRK 00571	C13	138	85	58	900	CA	QE										1/4	14
DRK 00593	C14	132	88	46	1100	CP	QE										1/8	15
DRK 00107	C17	89	114	55	1100	CA	QE										##########	16
DRK 00373	C17	88	77	56	600	CA	QE										1/5	:
DRK 00559	C17	160	138	119	2400	CA	QE										1/10	11
DRK 00329	F1	96	68	25	300	FA	QE	8	81	0	0	5	98		BTV		1/2	
DRK 00352	F1	92	90	28	90	FDE,FBL	QE	26	83	0	3	0	130	VTD			1/5	
DRK 00334	F1	70	93	27	100	FDL,FDE	QE	37	30	1	4	0	120	VTD			1/2	
DRK 00221	F3	68	118	31	300	FDE,FDL	QE	31	59	1	3	2	93			OD	1/7	
DRK 00301	F5	107	88	30	600	FA	QE	21	60	2	13	0	110	VTD			##########	
DRK 00533	F5	170	112	60	1100	FA	QE	40	78	1	7	0	130	VTD			##########	
DRK 00058	F14	133	124	60	1300	FA	QE	21	74	2	4	6	90				1/4	
DRK 00358	F19	90	68	30	200	FA	QE	gone	gone	gone	8	7	gone				1/10	
DRK 00170	U1	61	48	33	100	FDL	QE	23	30	1	8	0	135				##########	
DRK 00727	U1	68	84	30	489	FA	QE	9	82	gone	1	0	95				1/2	
DRK 00707	U1	131	110	44	1080	FDE	QE	35	84	2	3	0	125				1/3	
DRK 1971	U1	148	112	46	1100	FDL,FDE	QE	18	83	0	1	0	95				1/2	

Table 7. Field artifact information from Durkadi

Catalogue Number	Type	Length	Breadth	Thickness	Weight	Damage	Material	P. Thick.	P.Breadth	N.B.P.	N.D.S.	N.V.S.	P. Angle	VTD	DTV	OD	A.Cortex	N.F. Scars
NS V Tr.3:36	C13	107	95	37	650	CDE	LE										1/3	22
NS V Tr.3:43	C13	174	100	41	800	CP	LE										1/3	30
NS V Tr.3:38	C13	210	110	65	1000	CP	LE										1/4	24
NS VI Tr.1.17	C13	169	85	83	800	CDE	LE										1/3	22
NS V Tr.3.32	C13	132	70	45	500	CP	LE										##########	24
NS V Tr.3:29	C14	202	87	63	1200	CDE	LE										1/5	22
NS V Tr.3:42	C15	92	77	60	600	CA	LE										##########	15
NS V Tr.3:108	C15	77	73	32	284	CA	LE										##########	13
NS V Tr.3:83	C17	88	74	69	500	CSE	LE										1/4	12
NS VI Tr.1:282	C17	84	74	58	450	CA,CE	OE										1/2	5
NS VI Tr.1:3	C17	192	80	84	750	CA,CE	LE										1/2	12
NS V Tr.3:77	C17	109	100	100	1250	CSE	LE										1/8	14
NS V Tr.3:52	F2	188	91	43	800	FDL	LE	30	50	none		0	0	128	VTD			##########	
NS V Tr.3:56	F2	135	73	34	200	FDL	LE	35	41	none	none		0	135	DTV			##########	
NS V Tr.3:20	F2	120	80	40	450	FDE	LE	30	63	2		0	0	120	VTD			##########	
NS V Tr.3:24	F2	114	70	24	400	FDE	LE	18	24	none		0	4	115			OD	##########	
NS V Tr.3:20	F2	116	70	40	600	FDE	LE	46	16	2		0	0	126	VTD			##########	
NS V Tr.3:271	F7	80	62	17	100	FDE,FSL	LE	17	21	none		0	0	125	VTD			##########	
NS V Tr.3:127	F10	110	71	40	300	FDE,FDL	LE	50	32	none		0	0	90	VTD			1/6	
NS V Tr.3:30	F10	138	109	50	650	FA	LE	31	60	none		0	0	105	VTD			##########	
NS V Tr.3:27	F13	150	90	44	900	FDE	LE	40	65	none		12	0	118				1/6	
NS V Tr.3:83	U1	90	140	40	700	FDE	LE	40	70	none	none		0	120				##########	
NS V Tr.3:212	D1	57	41	15	60	No	LE	15	22	none	none		0	90				1/8	

Table 8. Field artifact information from Hunsgi

	LT	LS	SLT	DI	BS	GYD	BA	HI
C1	9	15	2	1	4		1	
C2	1	4	1		2			
C3	1		1	1	2			
C4								
C5	4	1	2		10			
C6								
C7		2	1		4			
C8			2	1		6		
C9	2	16	3	4			3	
C10					1			
C11		1				1		
C12								
C13	1	11		1	8	1	2	5
C14				1			1	1
C15		3				1	1	2
C16					1			
C17		8		3	1	1	1	4
F1	1	2	4	3		2		
F2	1	2			1			5
F3				1		7	1	
F4						1		
F5	1	1		2	1		1	
F6								
F7		1				1		1
F8		1	1			1		
F9		3	1					
F10			2			4		2
F11			1					
F12		4			1			
F13		1					1	1
F14	1	2		1		2		
F15						1		
F16					4		1	
F17								
F18		1						
F19				1				
F20						1		
F21		1						
F22								
F23								
U1	4	9	3	4	2	7		1
D1	1							1
D2	1	2						
Total	28	91	24	24	42	37	13	23

Table 9. Attributes of stone tool types from eight archaeological sites

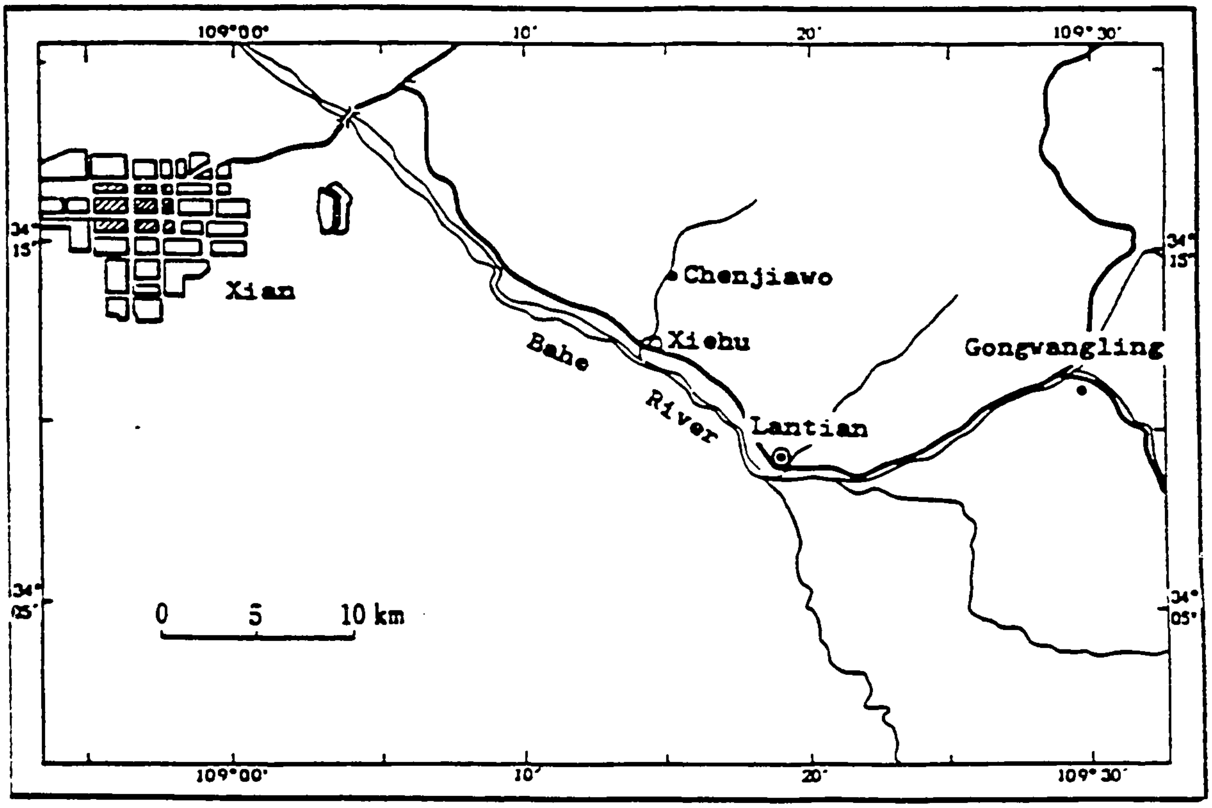


Fig. I 1. Map of Lantian area (An et al, 1989: Fig. 1).

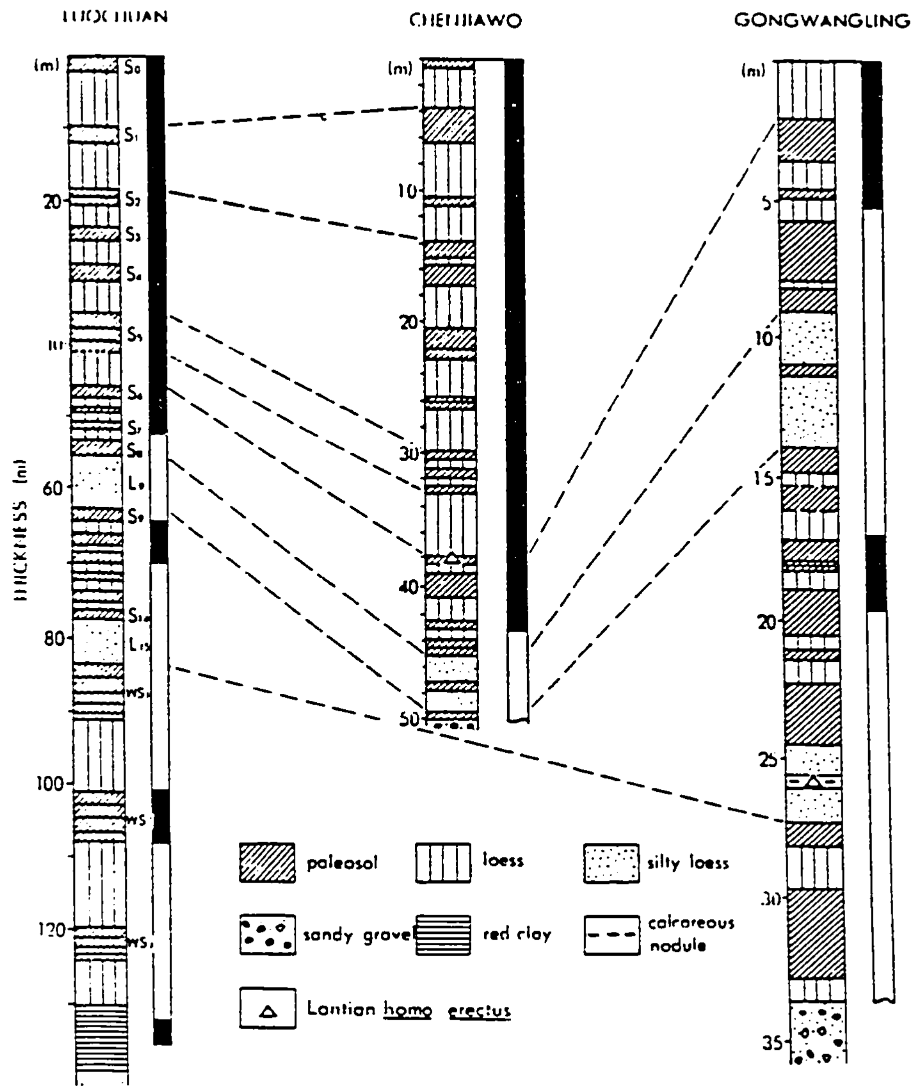


Fig. I 2. A comparison of the loess-paleosoil sequences at Gongwangling and Chenjiawo with the section in Luochuan (An et al, 1989: Fig. 5).

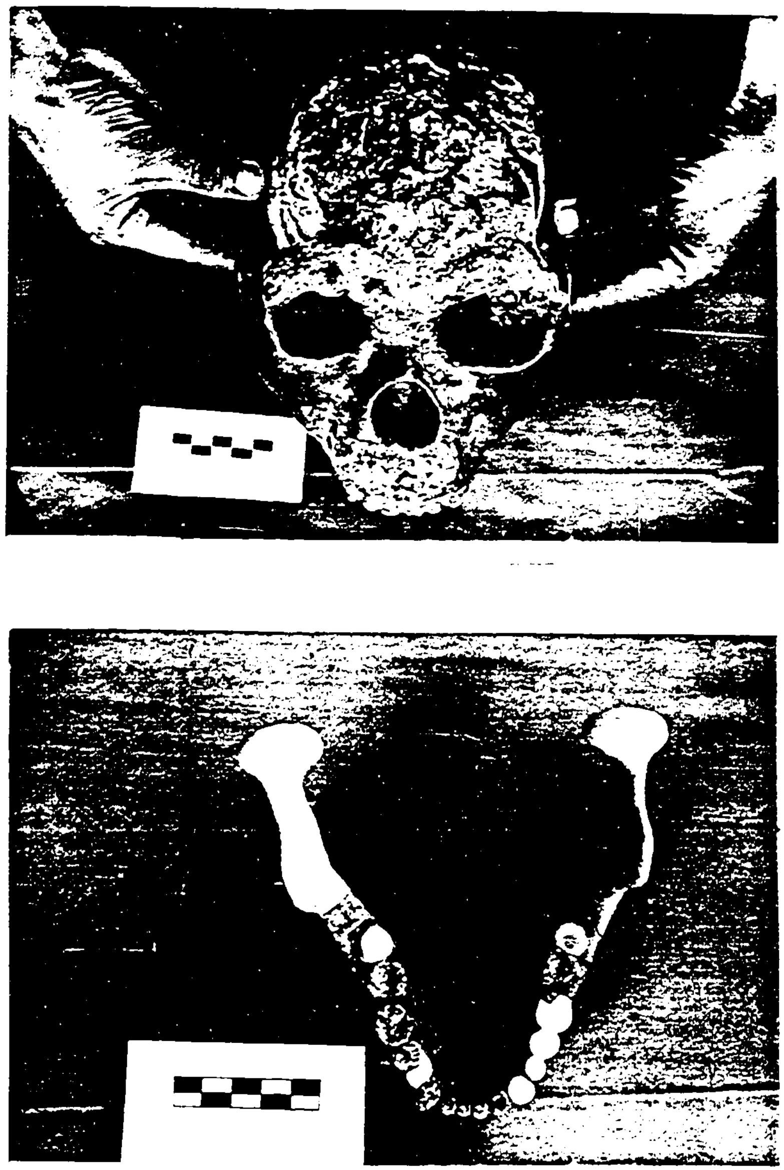


Fig. I 3. Lantian skull and mandible.

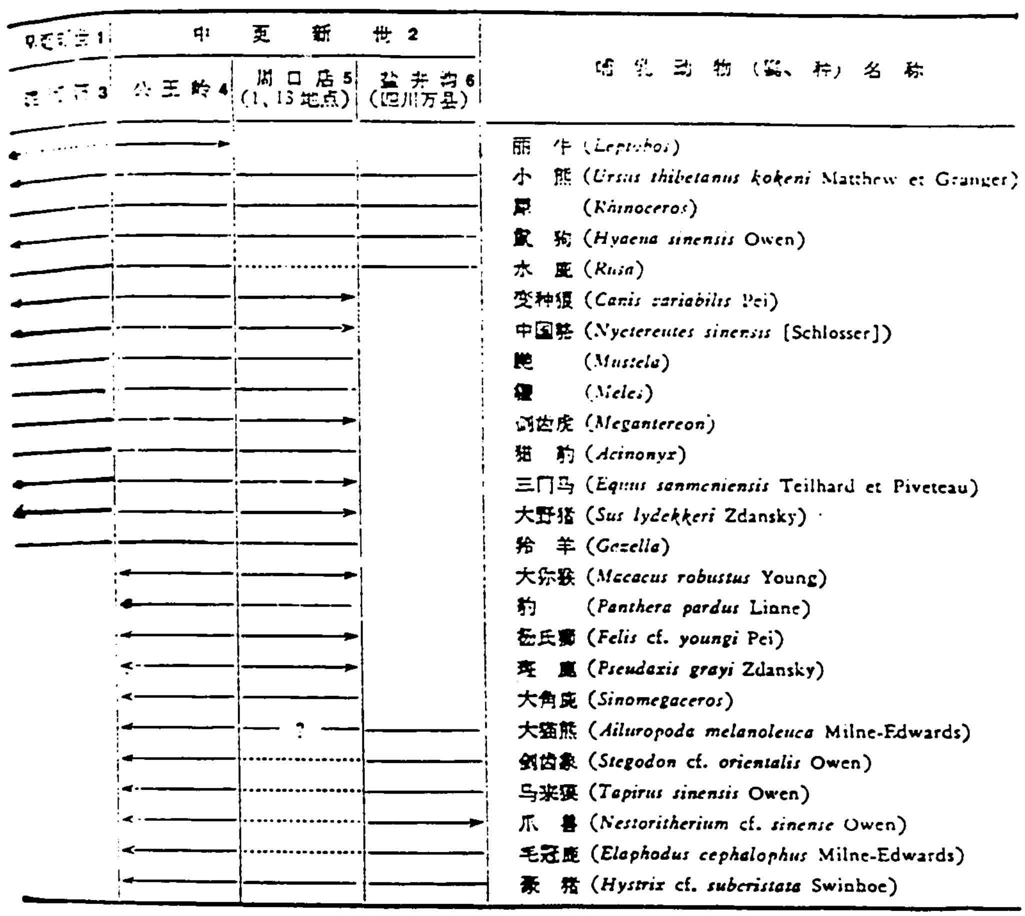


Fig. I 4. The distribution of Gongwangling Fauna in Early and Middle Pleistocene (Zhou, 1965: Table 1). Key: 1. Early Pleistocene 2. Middle Pleistocene 3. Nihewan 4. Gongwangling 5. Zhoukoudian (Location 1, 13) 6. Yanjinggou

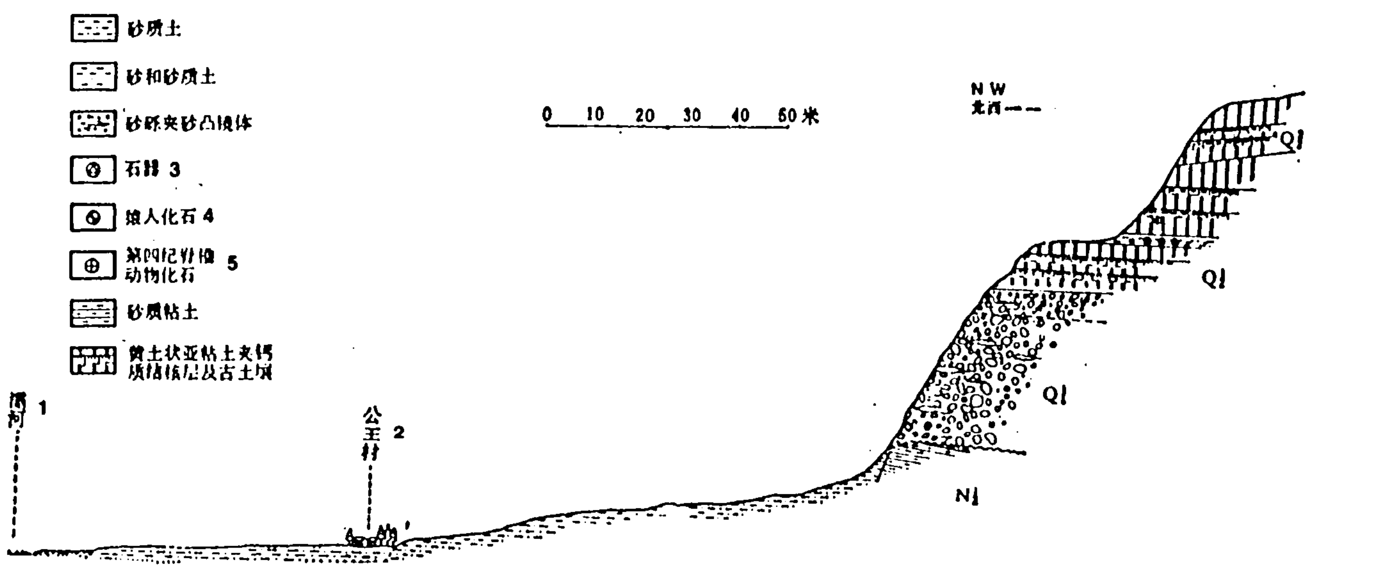


Fig. I 5. The stratigraphy of Gongwangling fossil beds (Zhang, 1978: Fig. 28). Key: 1. Ba River 2. Gongwangling 3. Artifacts 4. Hominid remains 5. The faunal remains

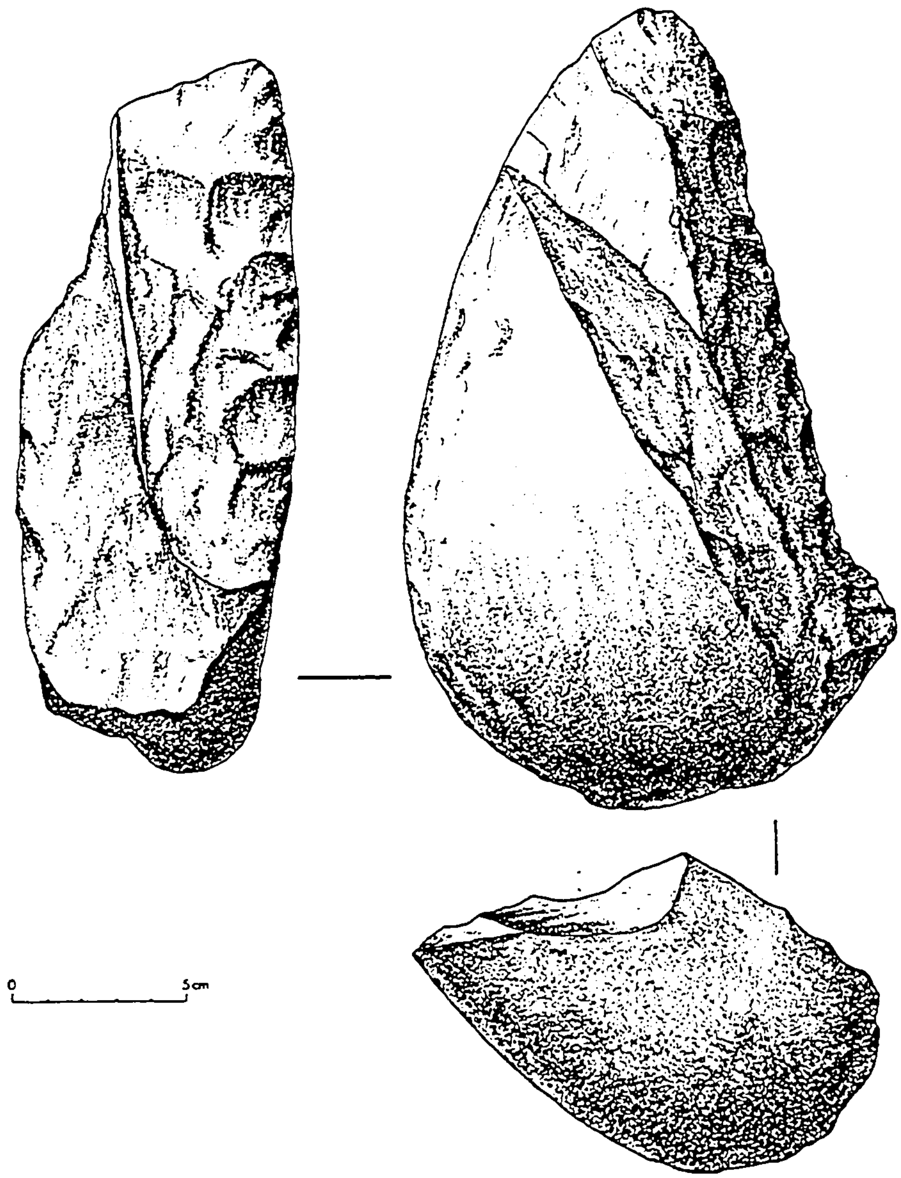


Fig. I 6. Tool of type C1 (P3857) from Lantian.

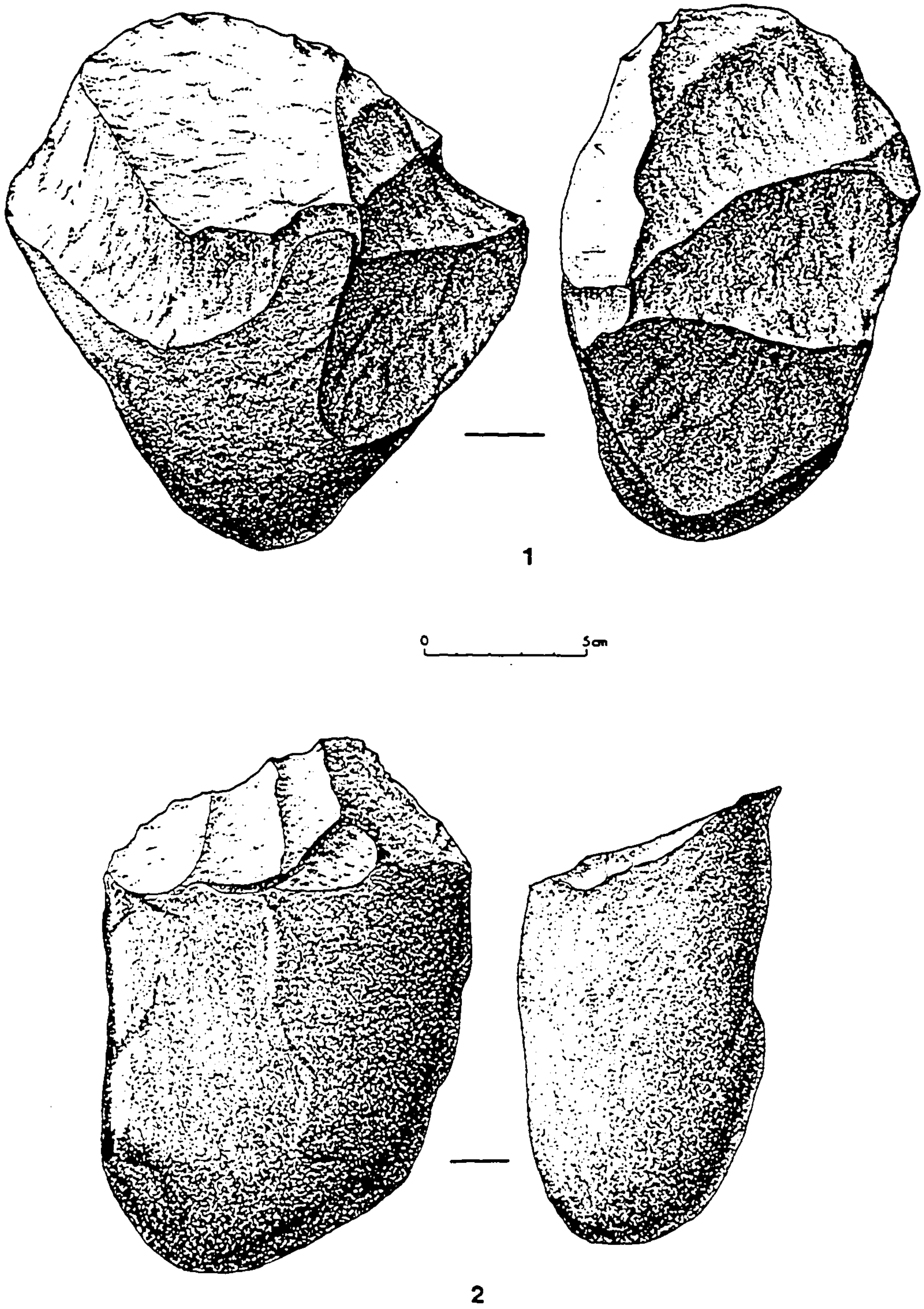


Fig. I 7. Tools of type C1 (1. P3847 2. P3850) from Lantian.

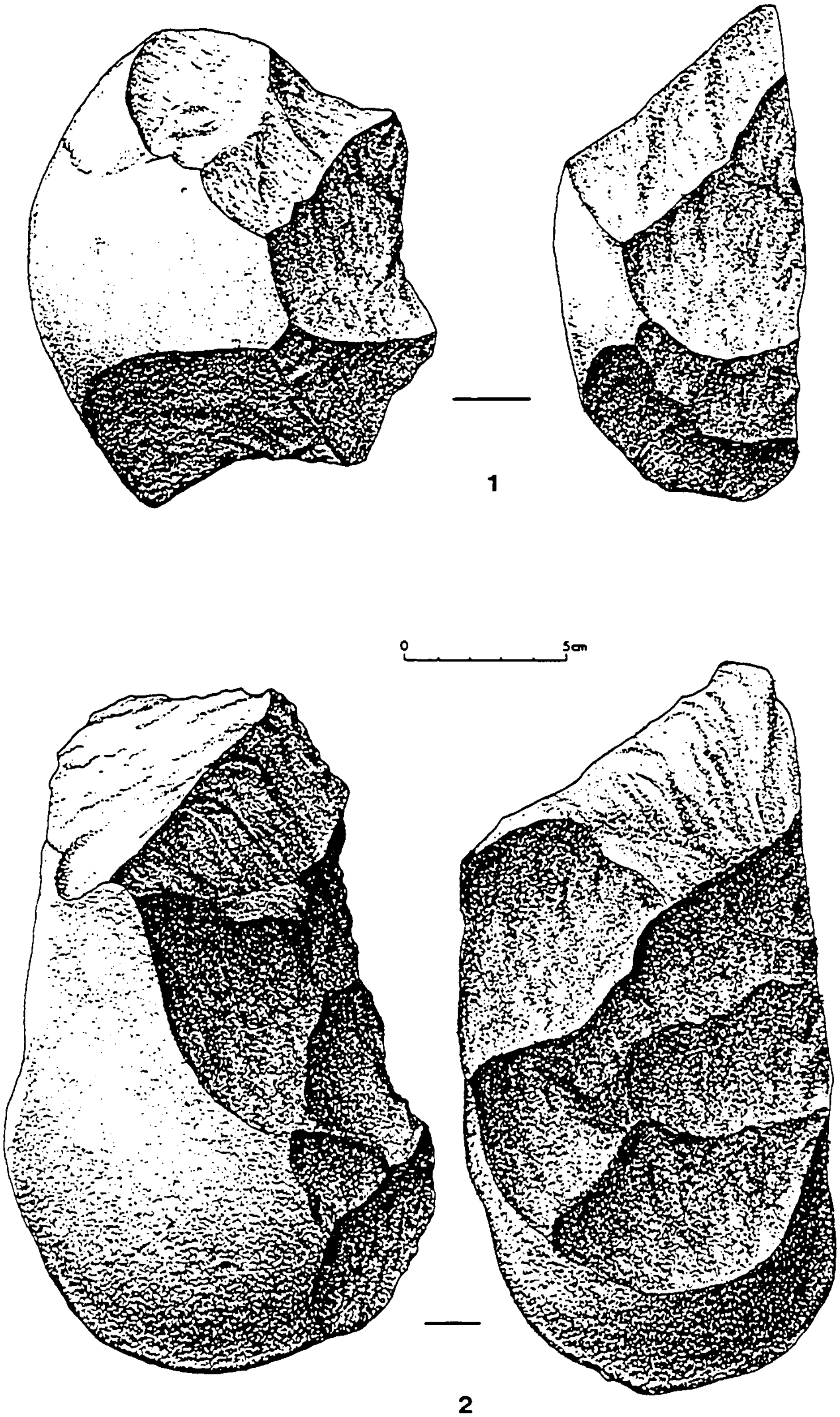


Fig. I 8. Tools of type C1 (1. P3858 2. P3848) from Lantian.

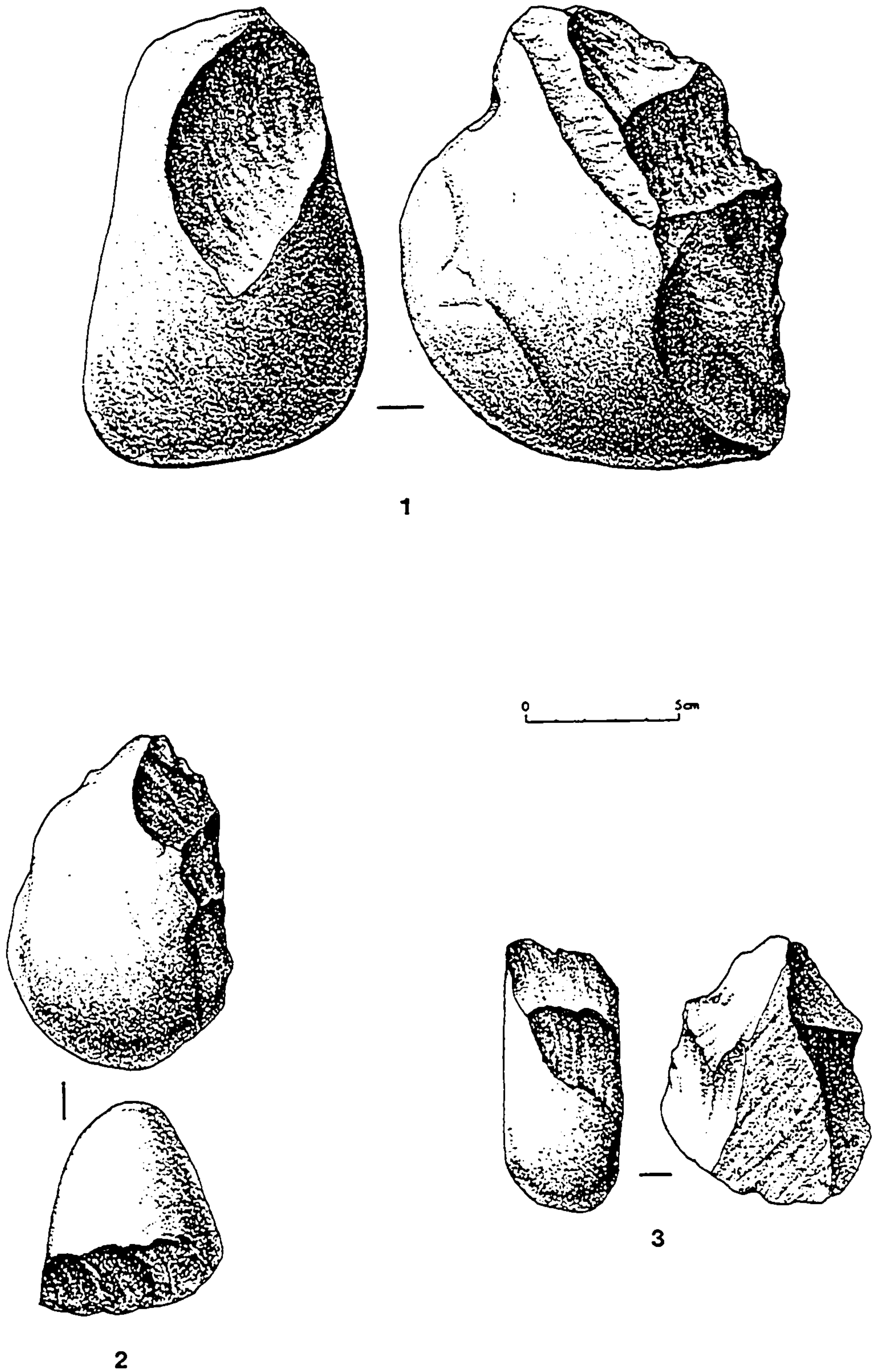


Fig. I 9. Tools of type Cl (1. P3466 2. P3849 3. P3874) from Lantian.

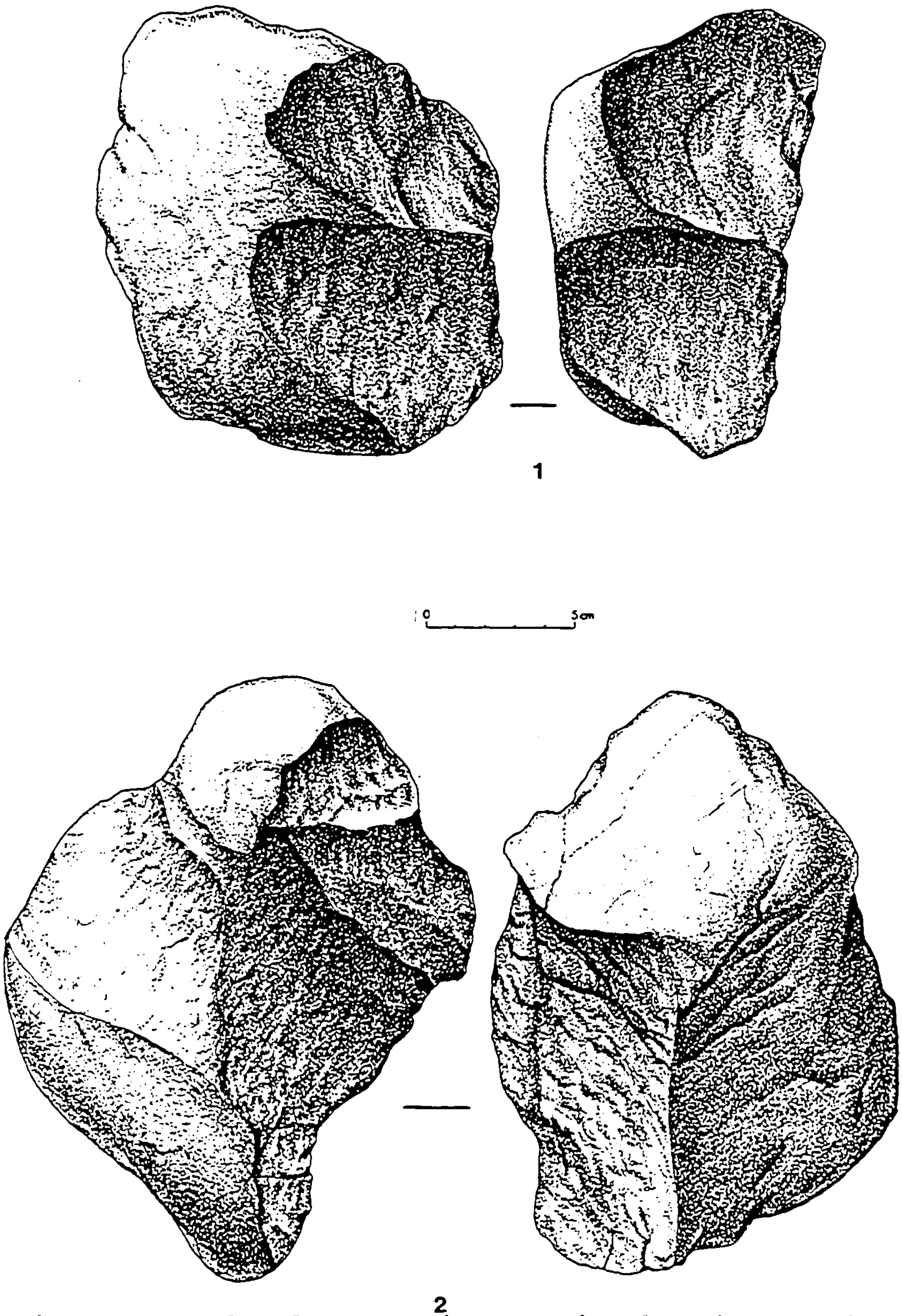


Fig. I 10. Tools of type C1 (1. P3846) and C2 (2. P3851) from Lantian.

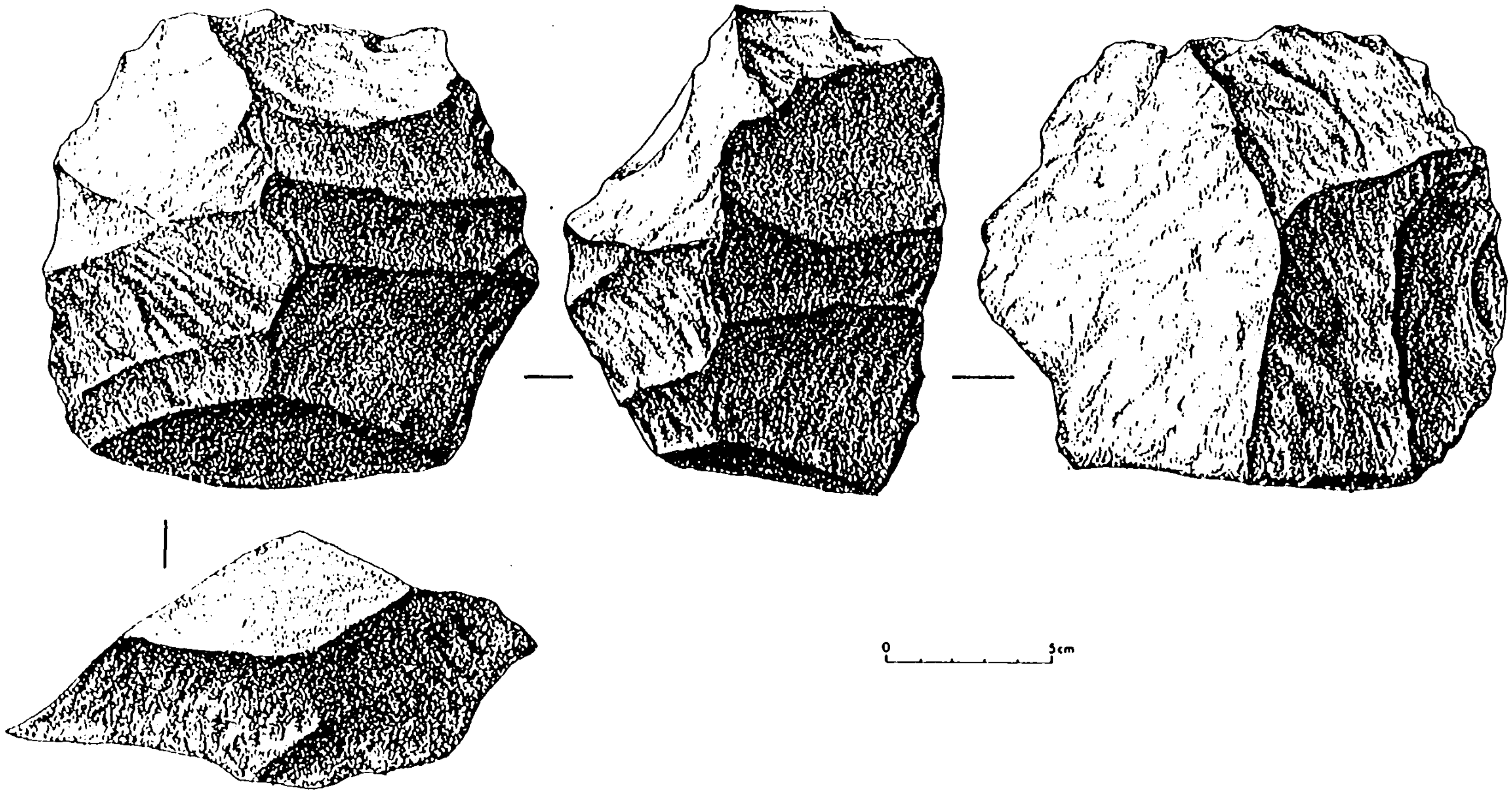


Fig. I 11. Tool of type C3 (P3861) from Lantian.

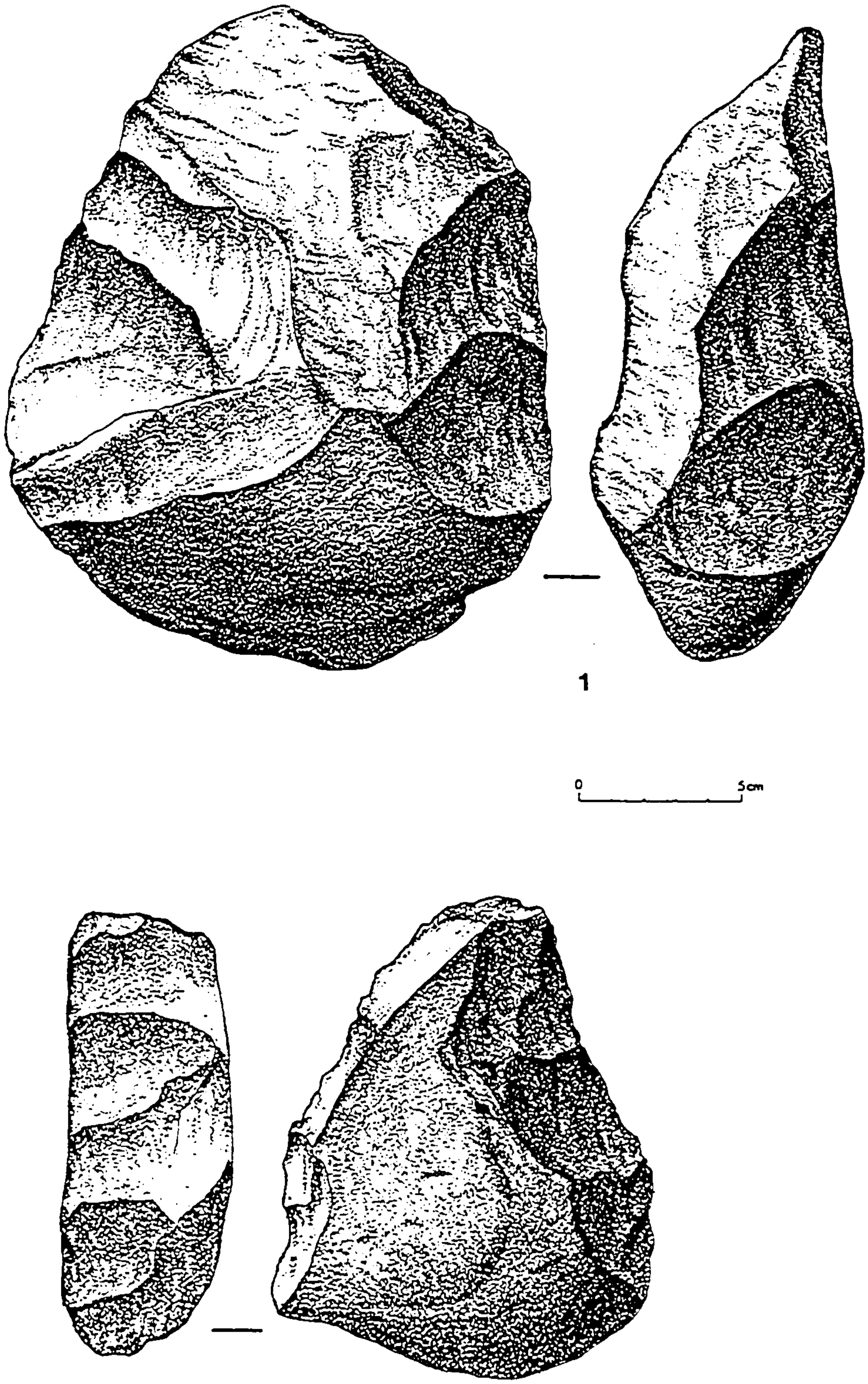


Fig. I 12. Tools of type C5 (1. P3878 2. P3864) from Lantian.

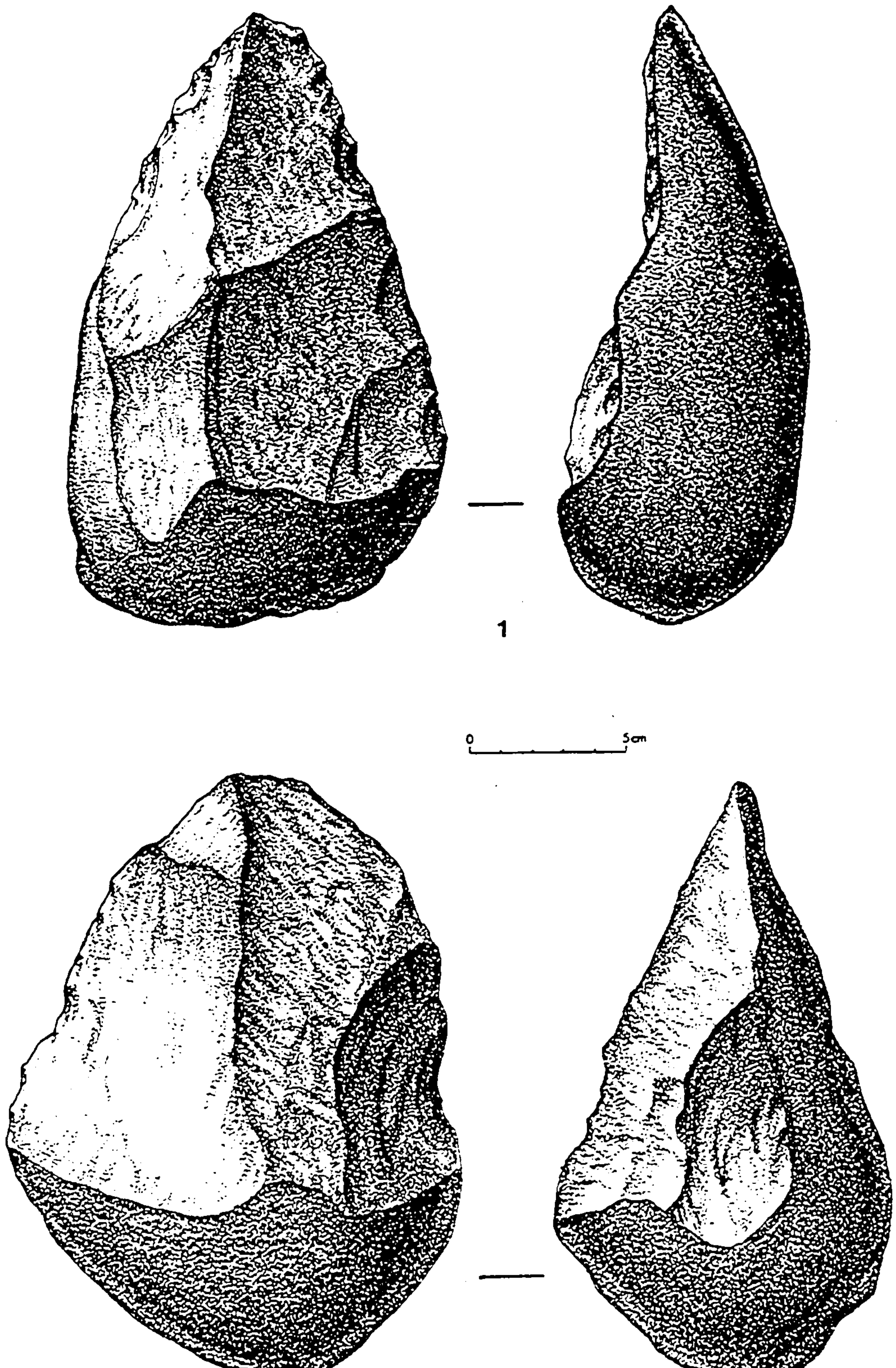


Fig. I 13. Tools of type C5 (1. P2875 2. P3865) from Lantian.

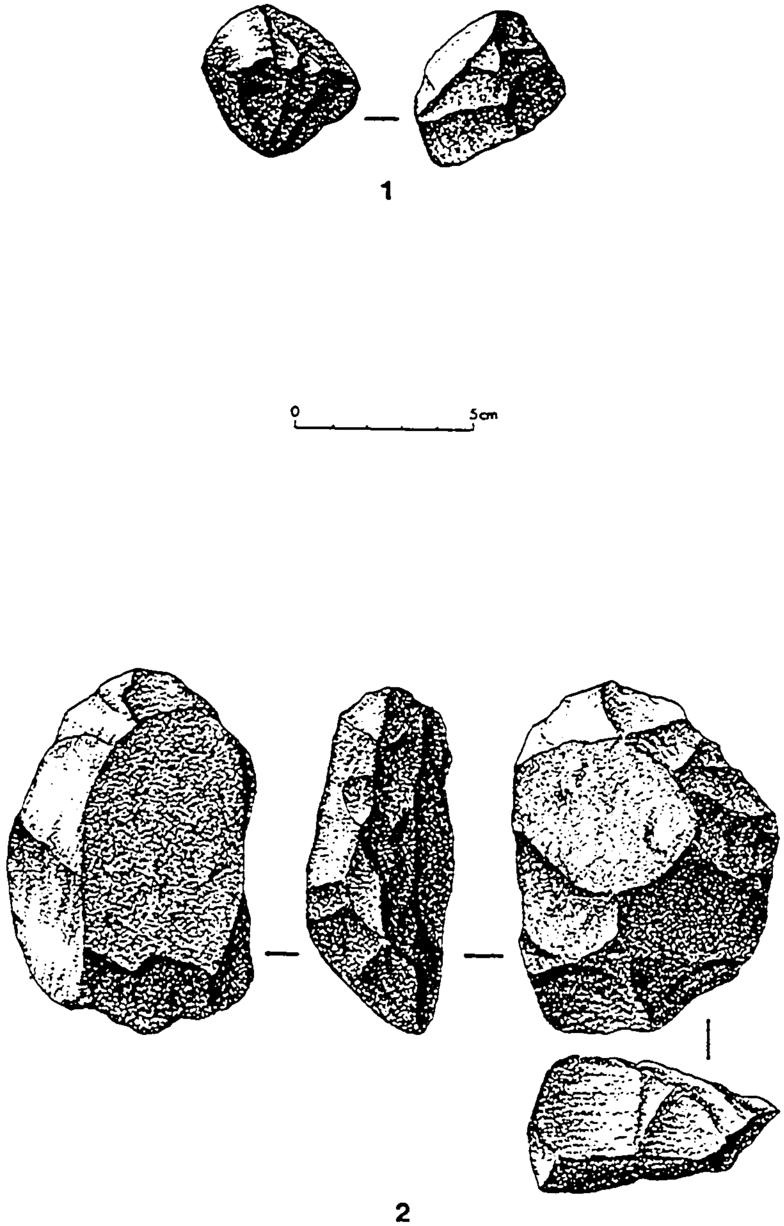


Fig. I 14. Tools of type C9 (1. P3465 2. P3860) from Lantian.

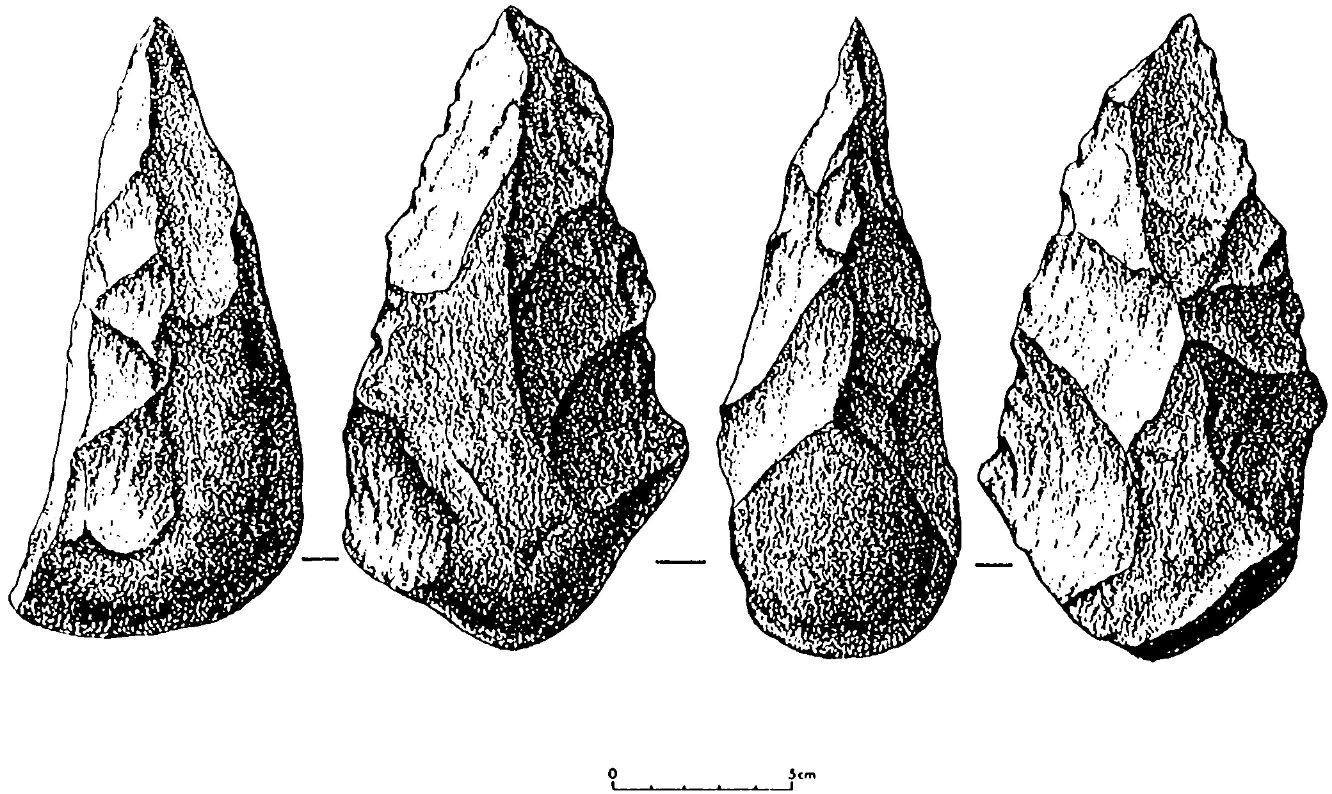


Fig. I 15. Tool of type C13 (P3468) from Lantian.

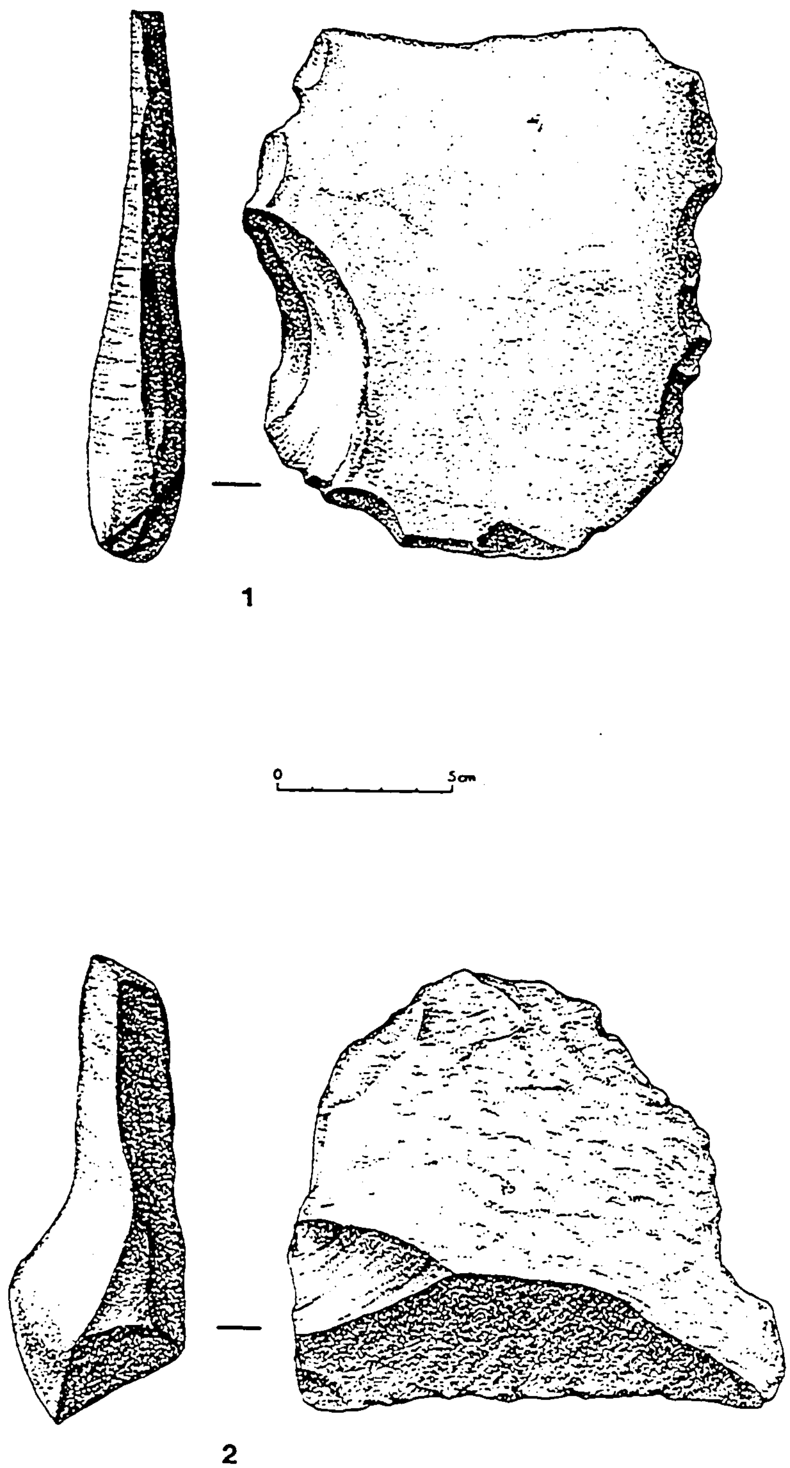


Fig. I 16. Tools of type F2 (1. P3877) and F1 (2. P3871) from Lantian.

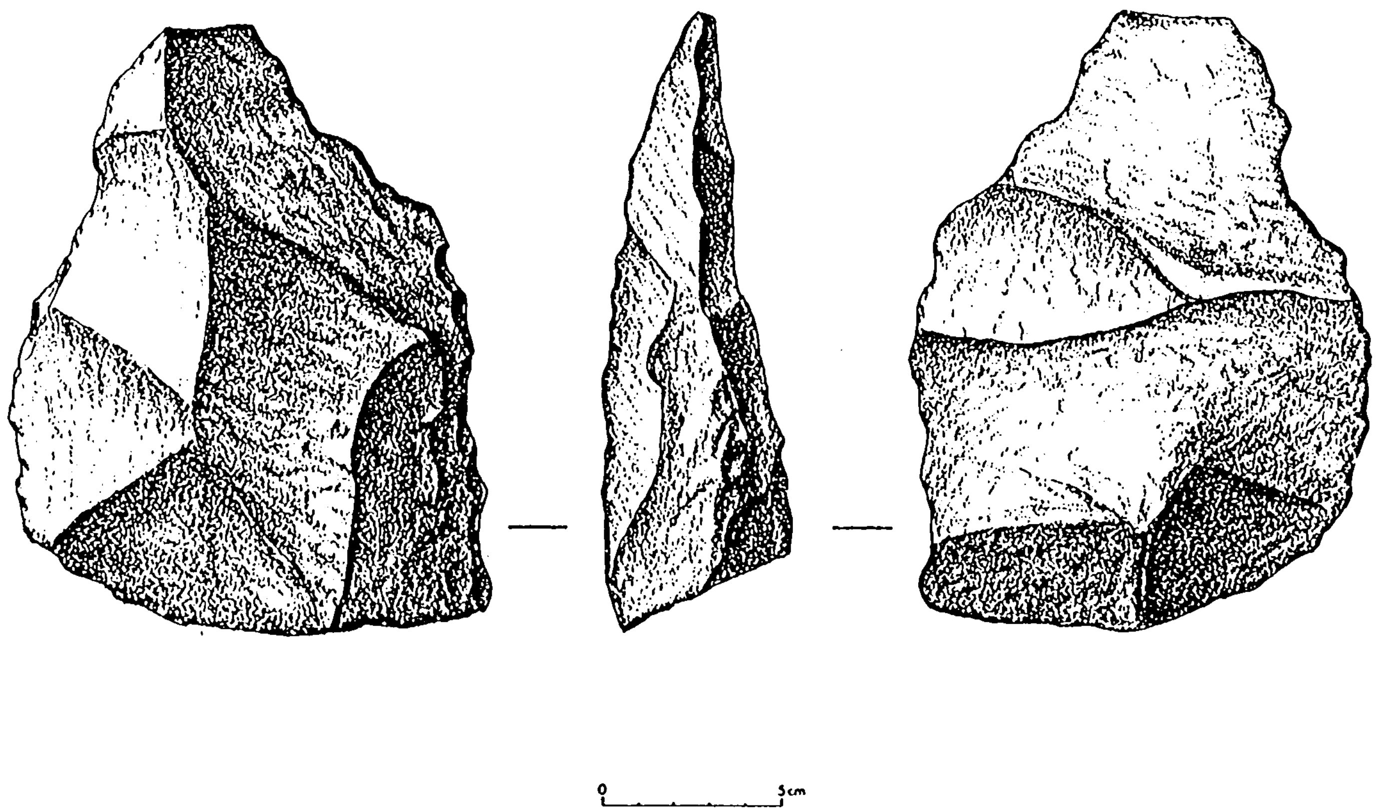


Fig. I 17. Tool of type F5 (P3467) from Lantian.

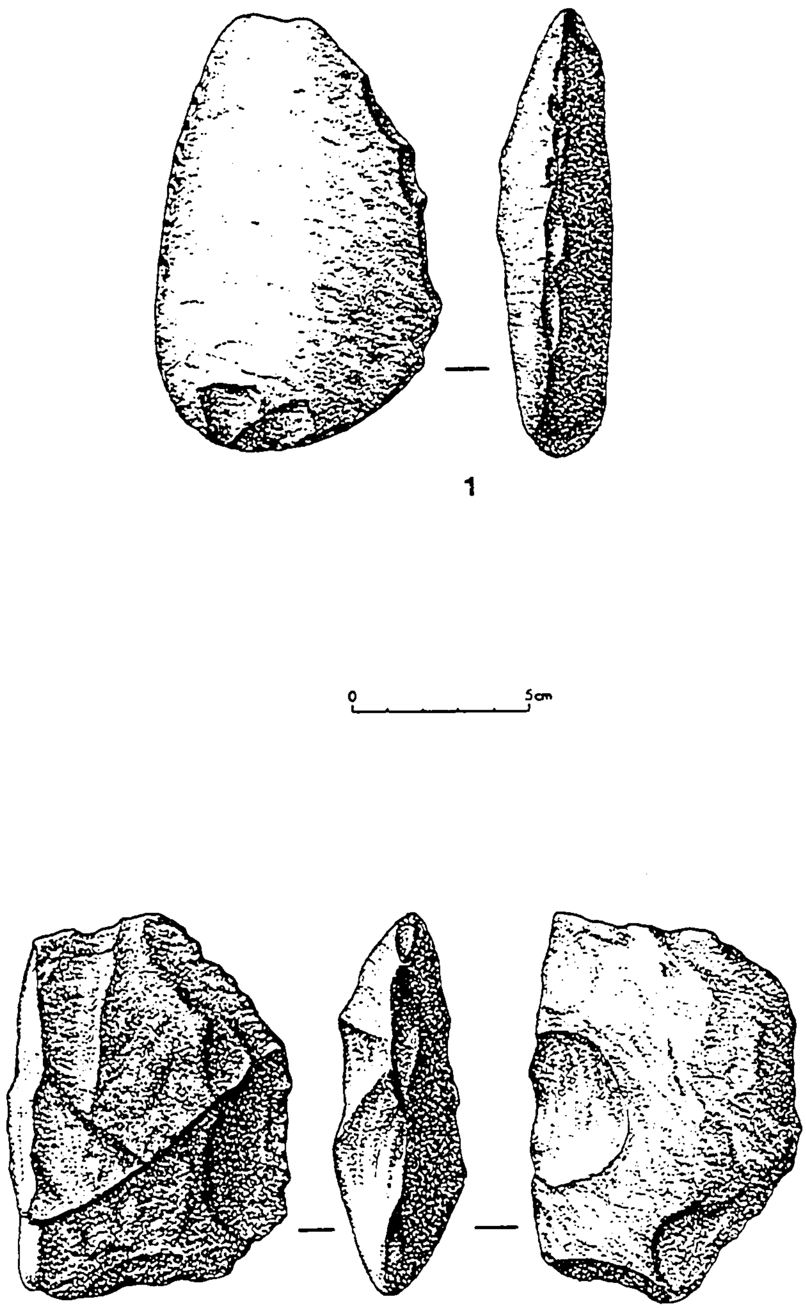


Fig. I 18. Tools of type U1 (1. P3873) and F14 (2. P3867) from Lantian.

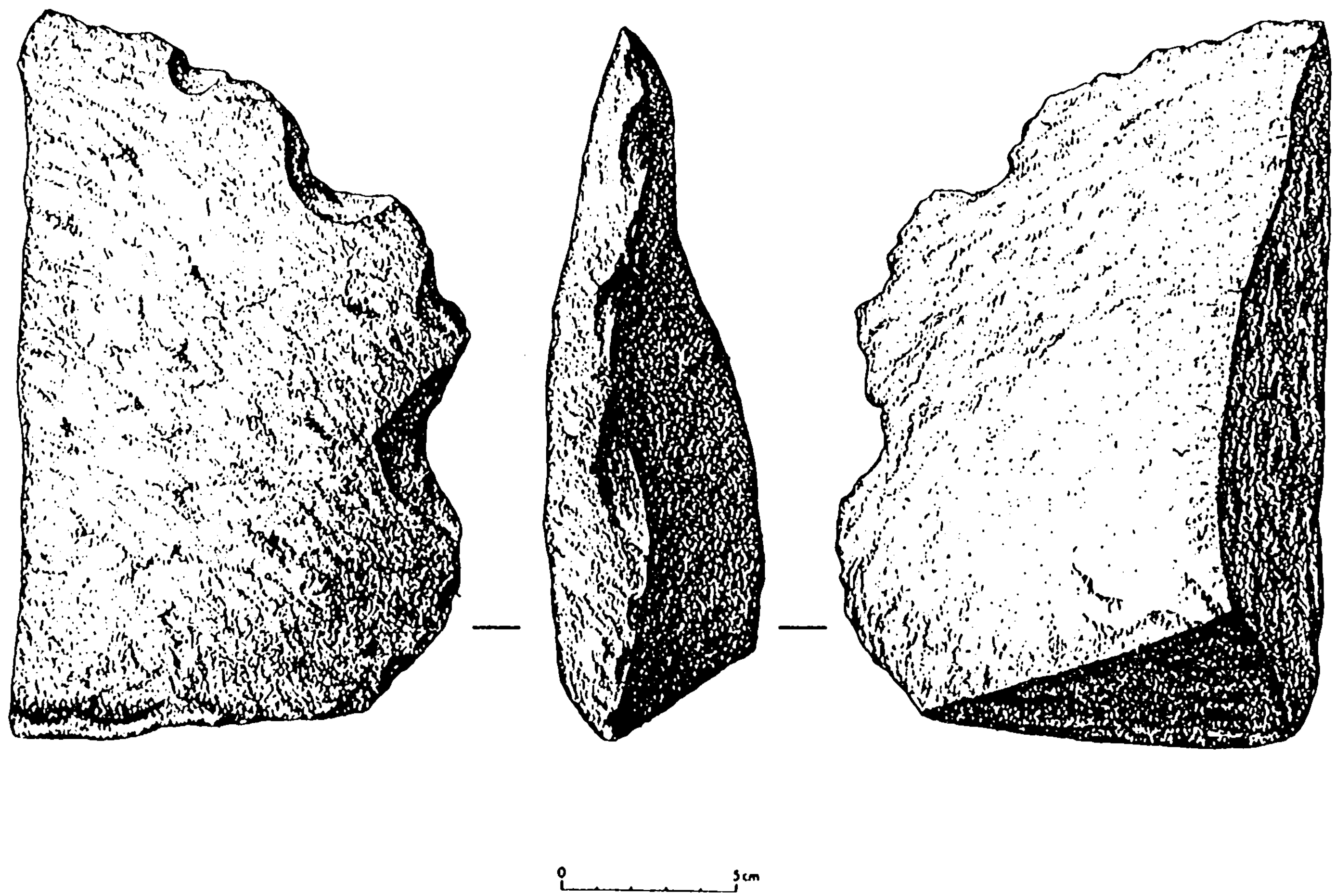


Fig. I 19. Tool of type U1 (P3876) from Lantian.

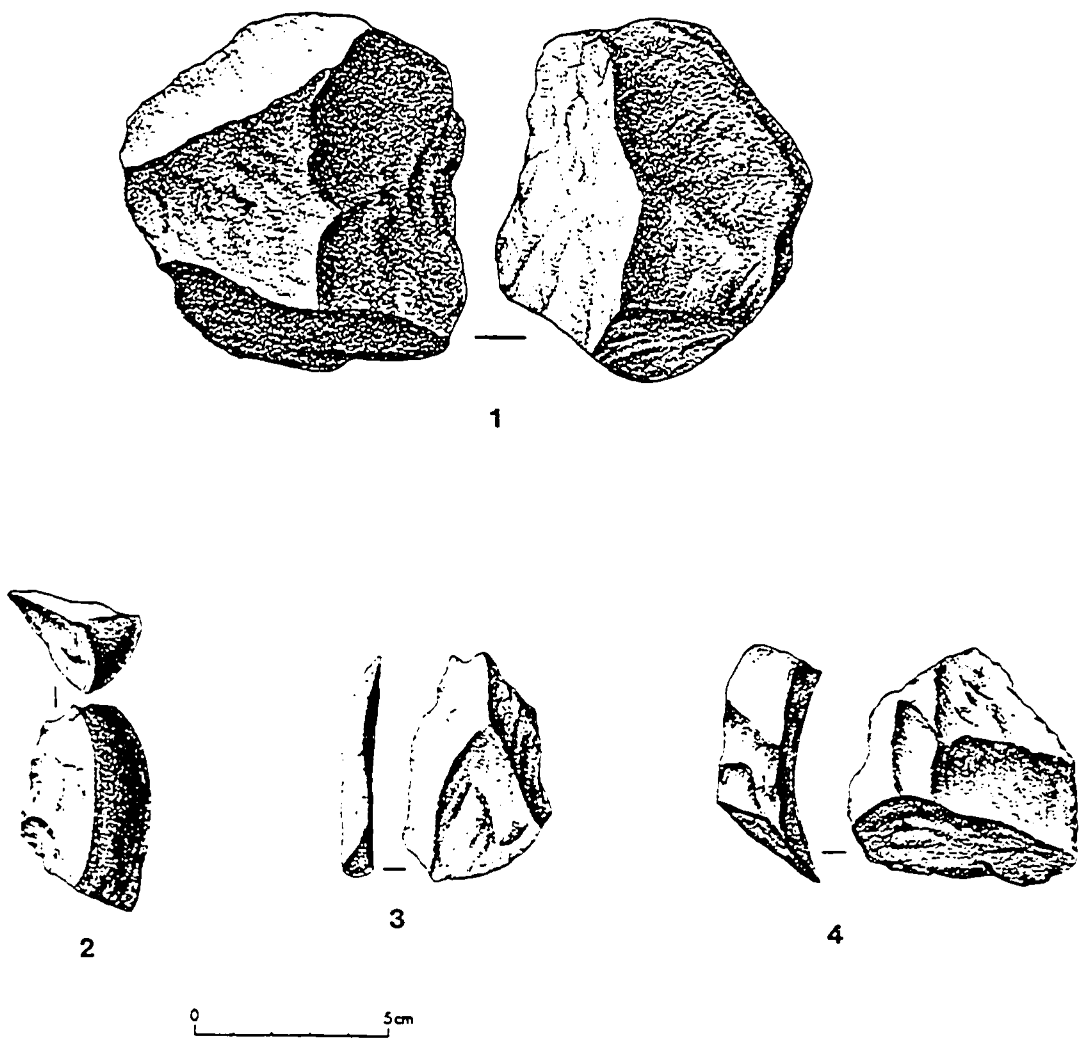


Fig. I 20. Tools of type U1 (1. P3855 3. P3856), D1 (2. P3852) and D2 (4. P3879) from Lantian.

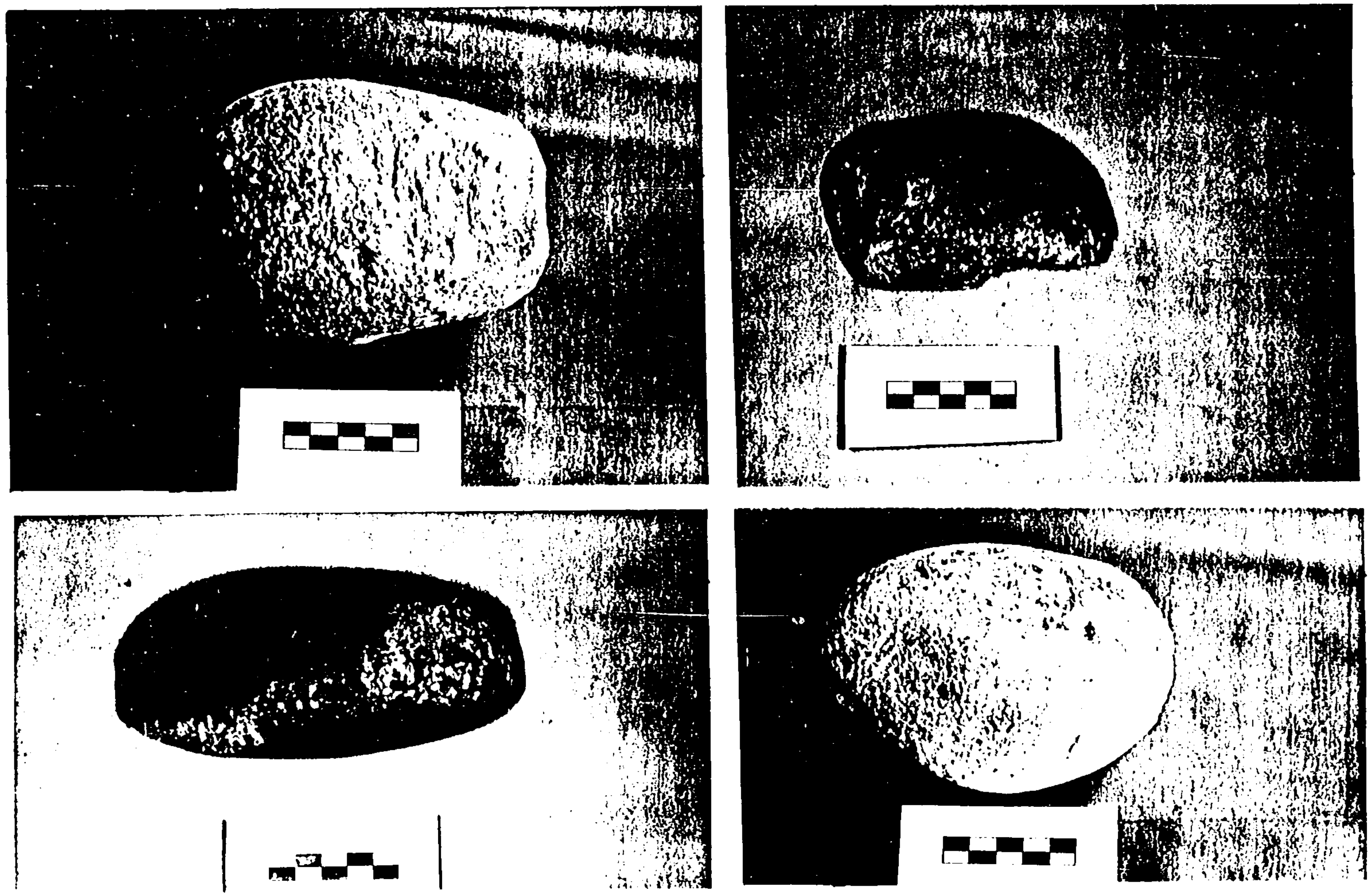


Fig. I 21. Cobbles used in the replicative studies, Lantian.

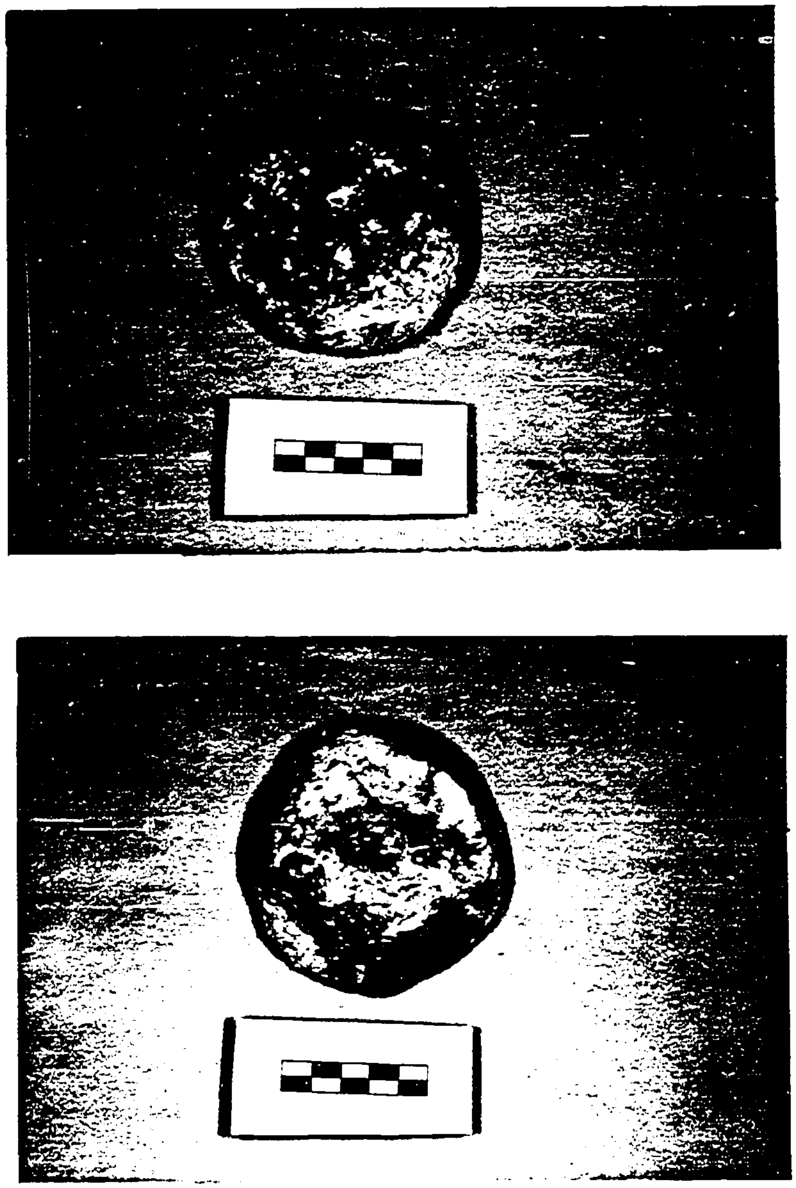
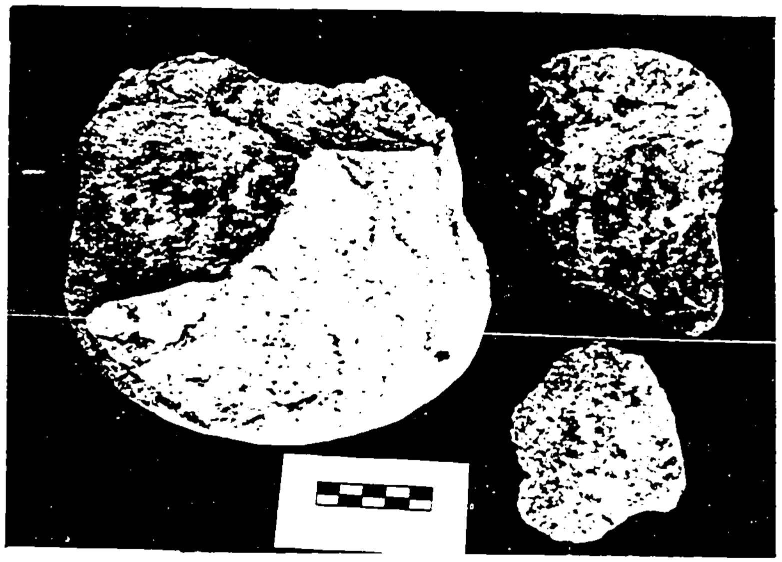


Fig. I 22. Hammerstones used in the replicative studies, Lantian.



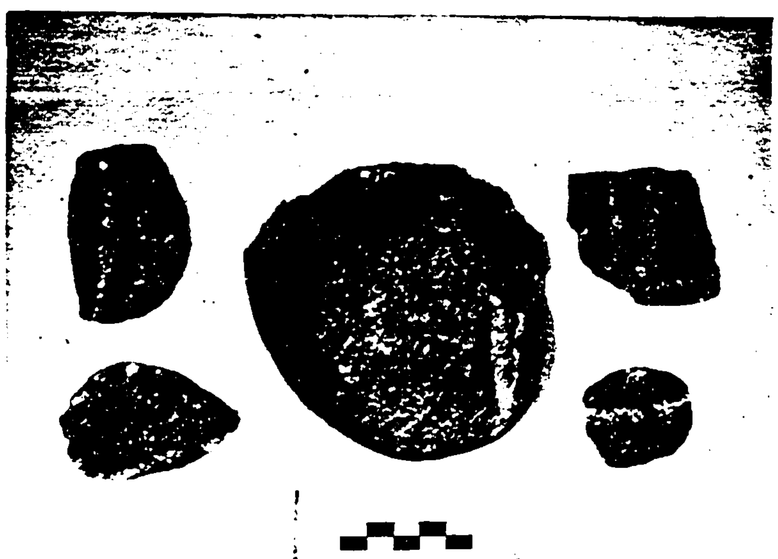


Fig. I 23. Replication: Cl, of Lantian.

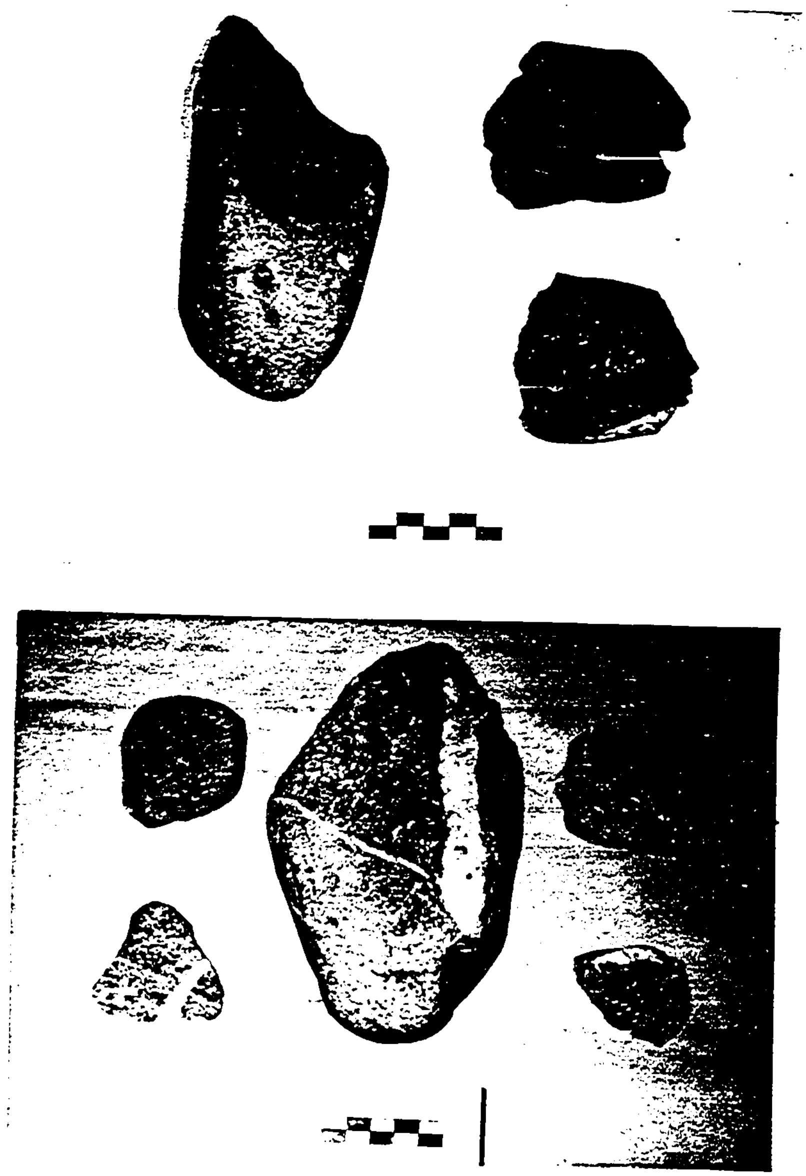


Fig. I 24. Replication: Cl, of Lantian.

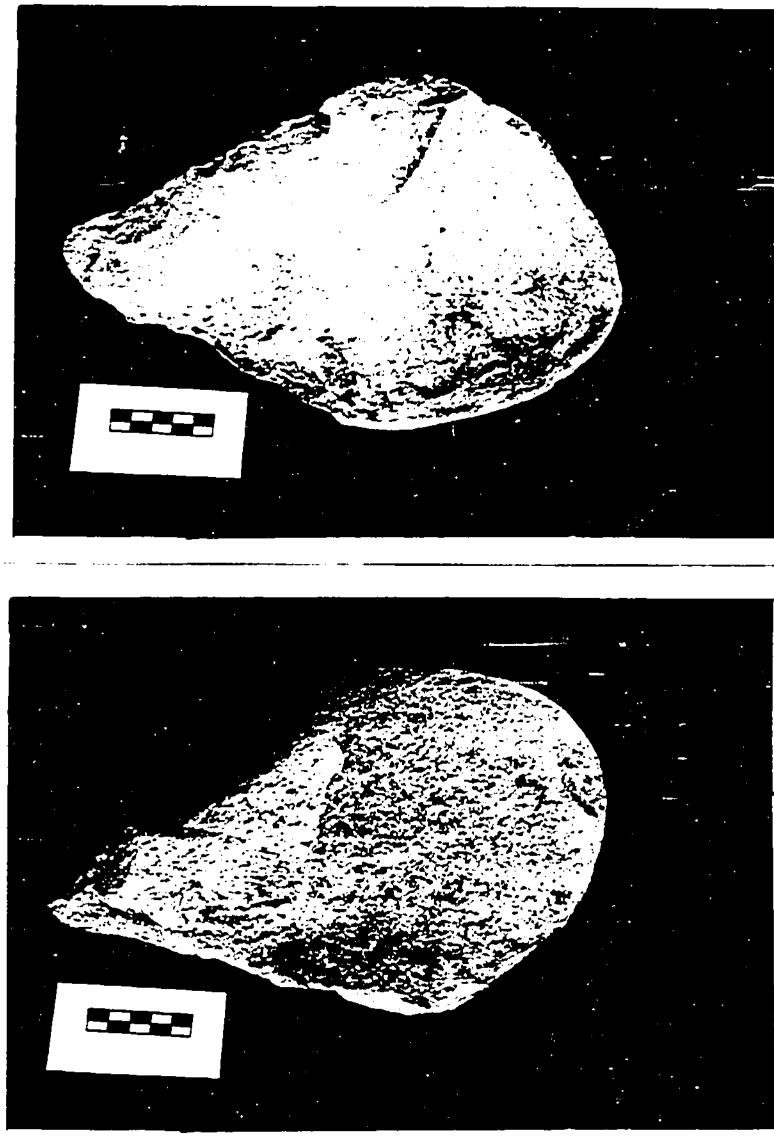


Fig. I 25. Replication: C5, of Lantian.

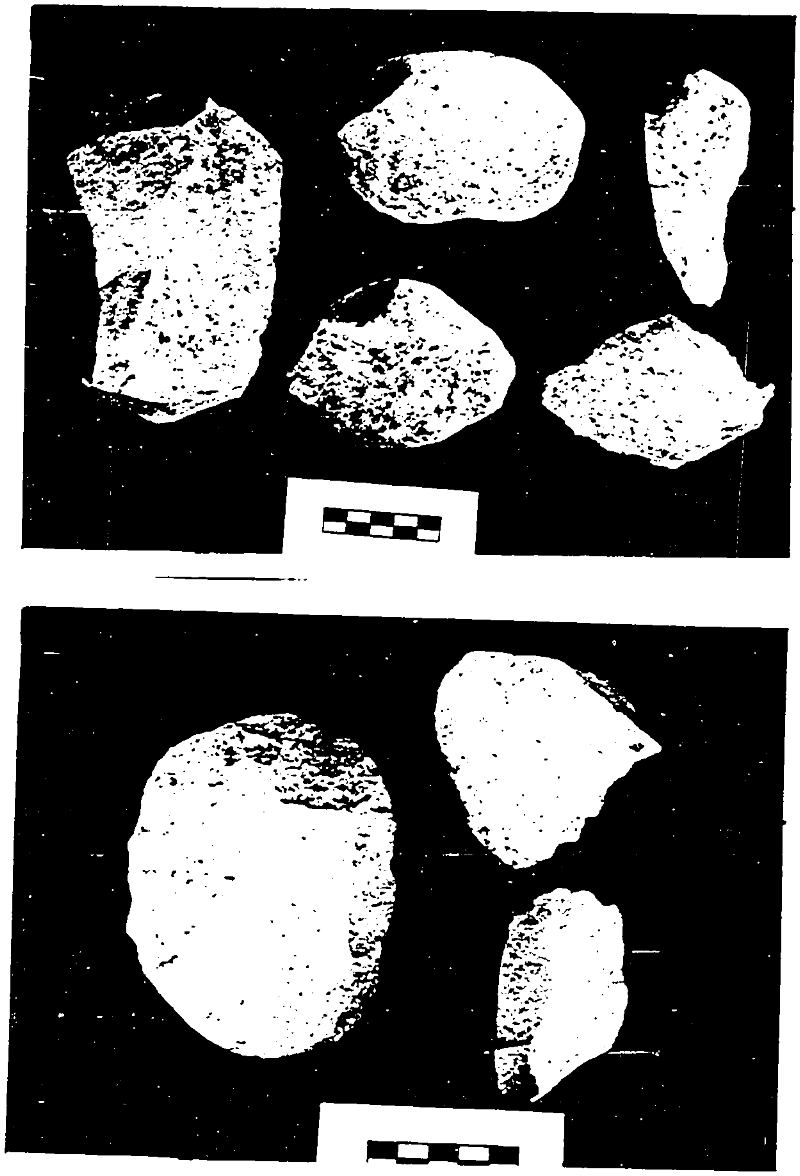


Fig. I 26. Replication: C3, of Lantian.

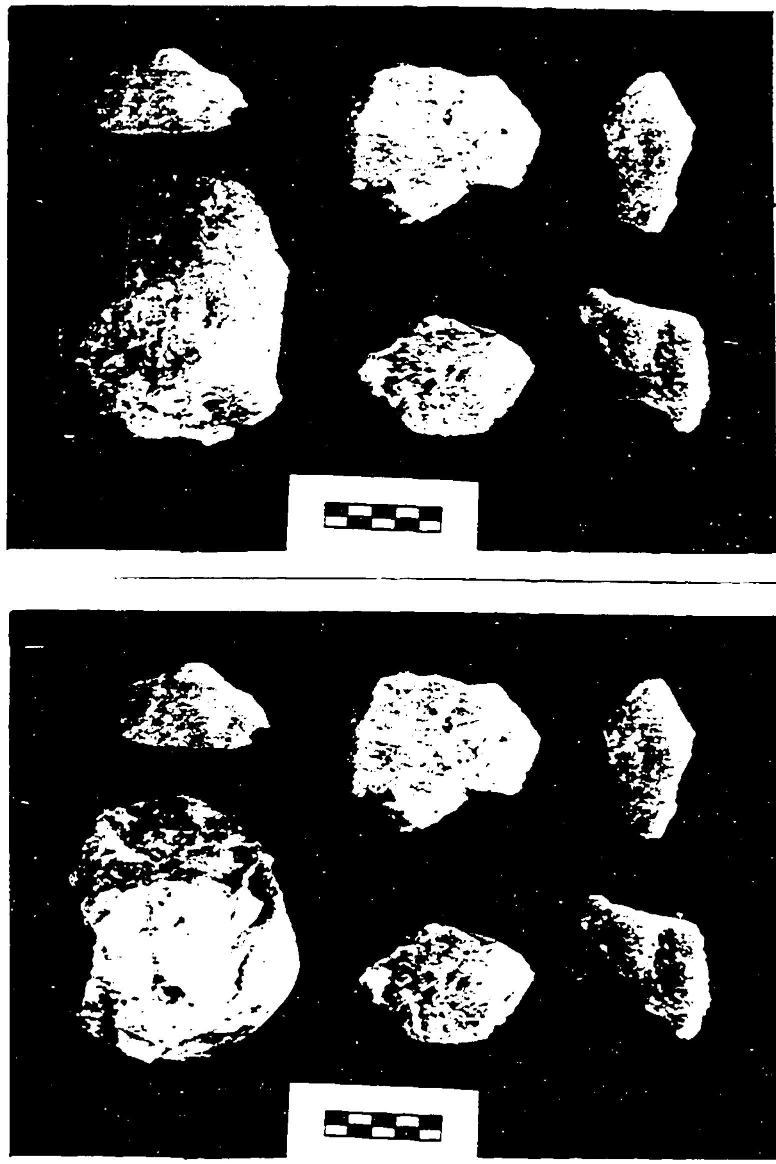


Fig. I 27. Replication: C9, of Lantian.

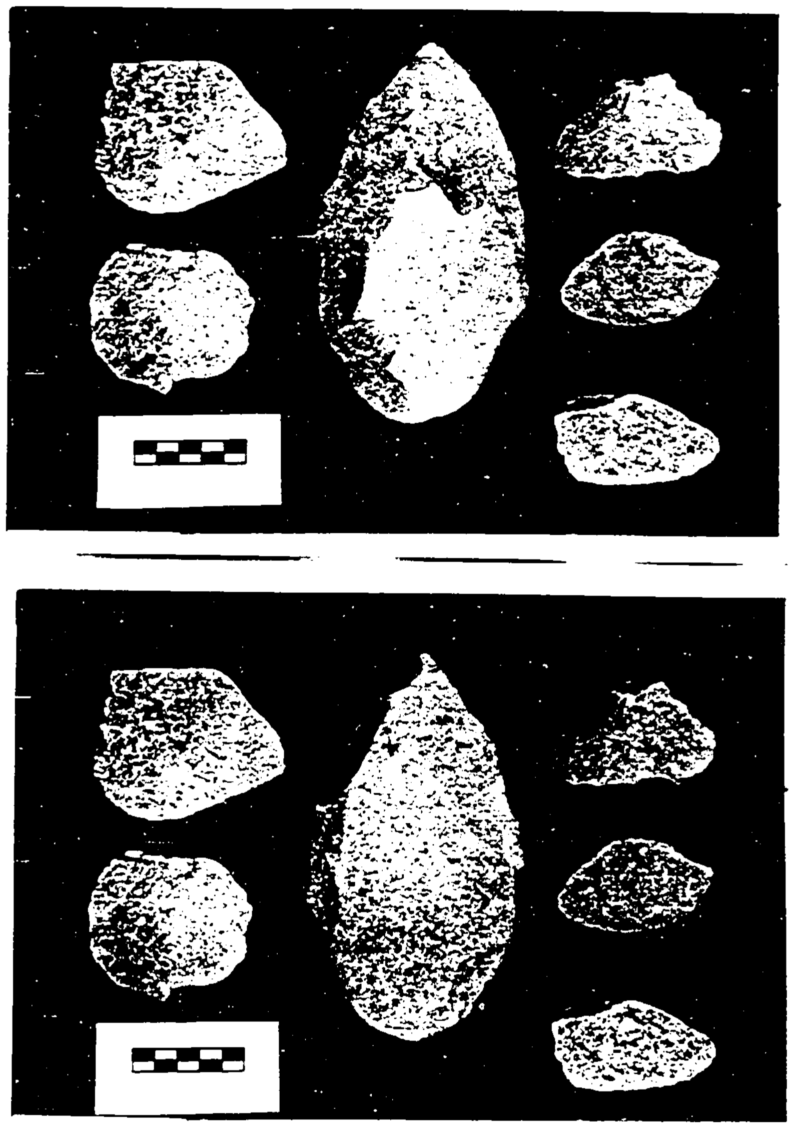


Fig. I 28. Replication: C13, of Lantian.

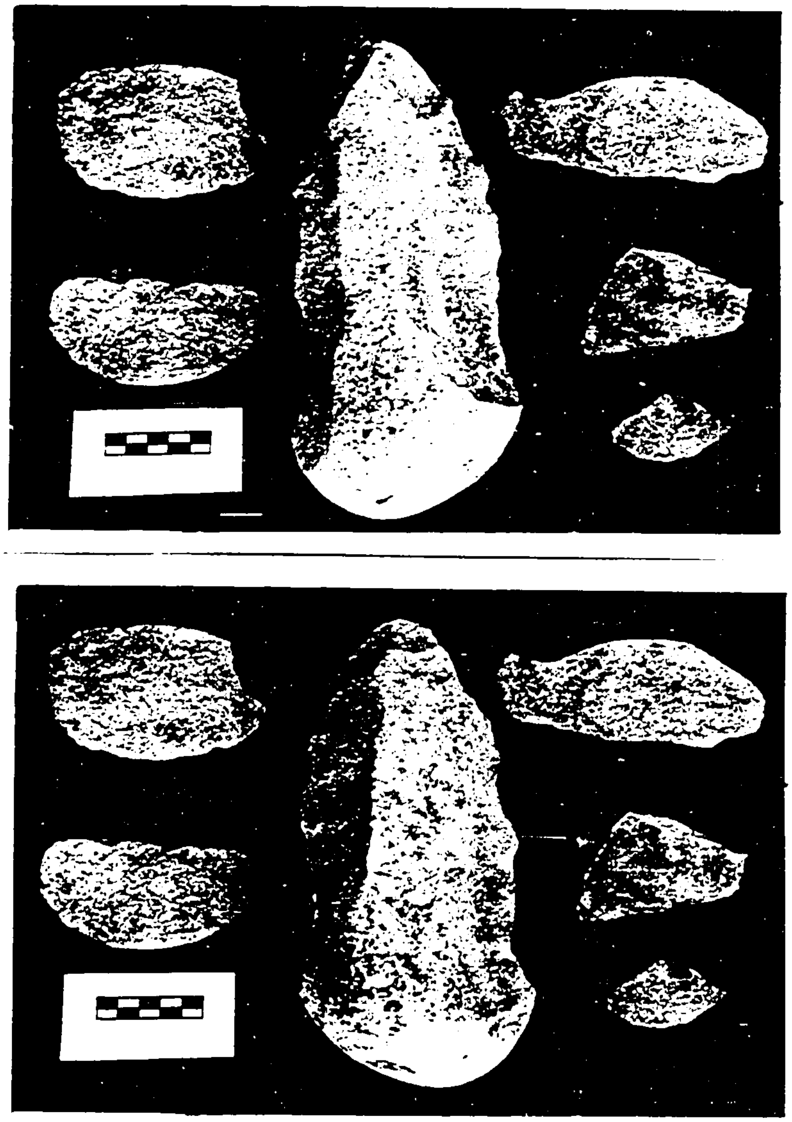


Fig. I 29. Replication: C13, of Lantian.

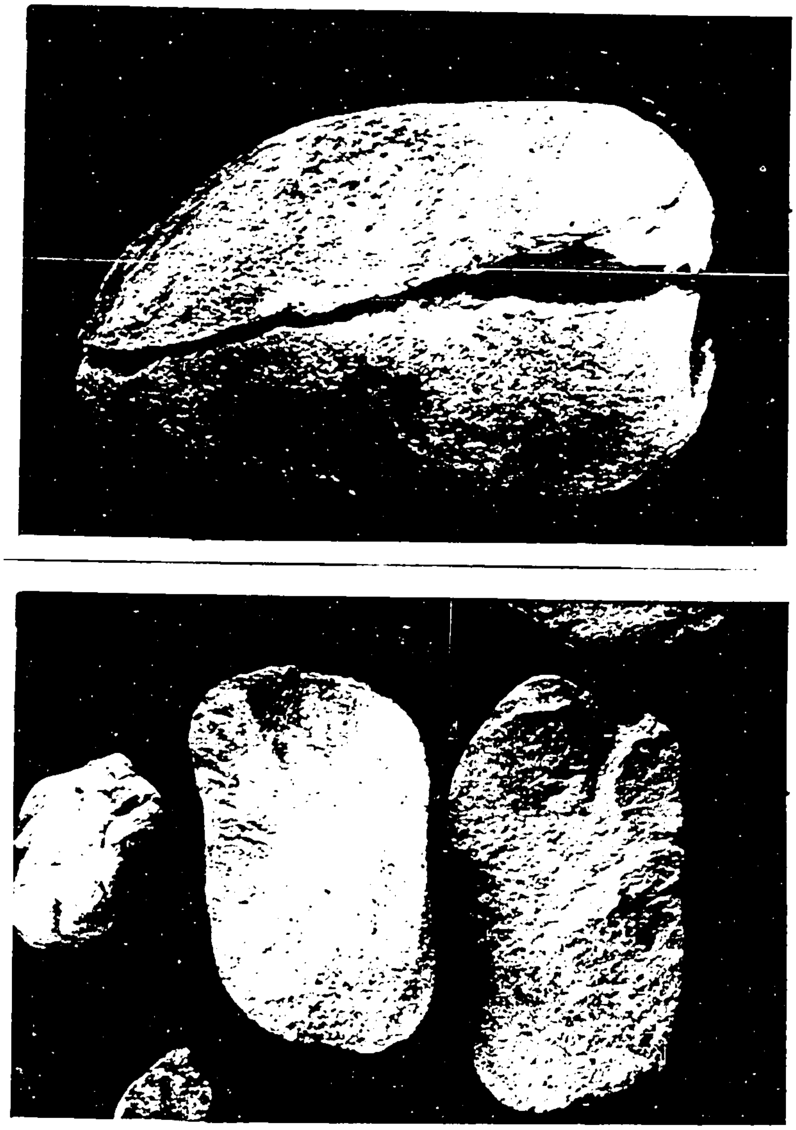


Fig. I 30. Replication: a boulder (270x146x100 mm.) broken in half, Lantian.

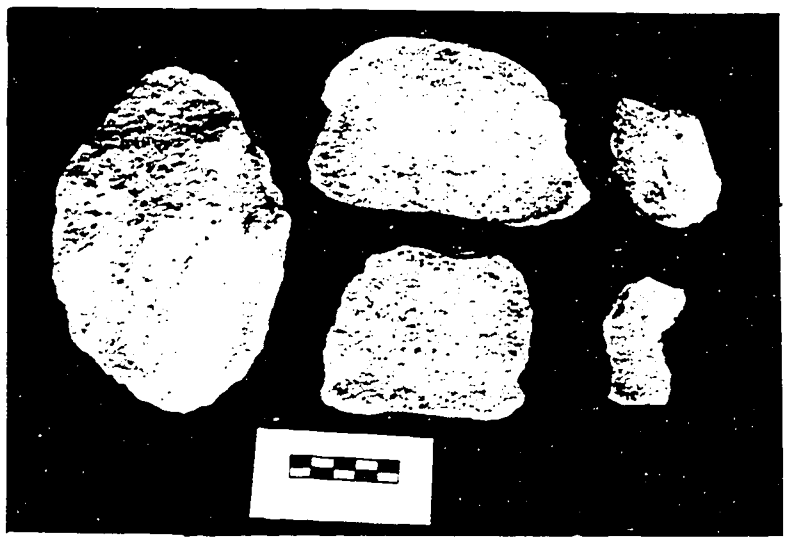


Fig. I 31. Replication: the largest flake is almost as large as the core tool.

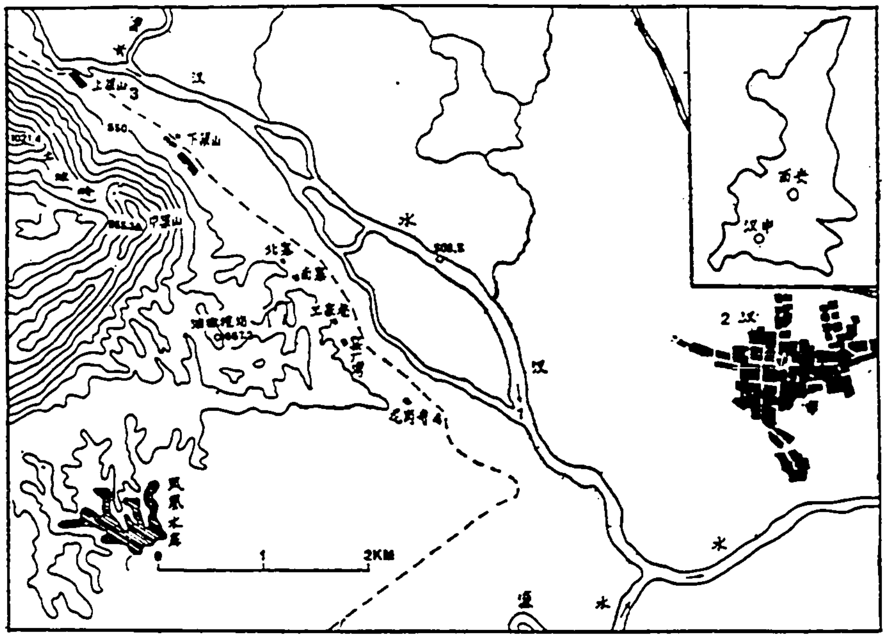


Fig. II 1 . Geographic position of Liangshan site (Huang, 1987: Fig. 1). Key: 1. Hanshui River 2. Hanzhong city 3. Upper Liangshan 4. Longgangsi

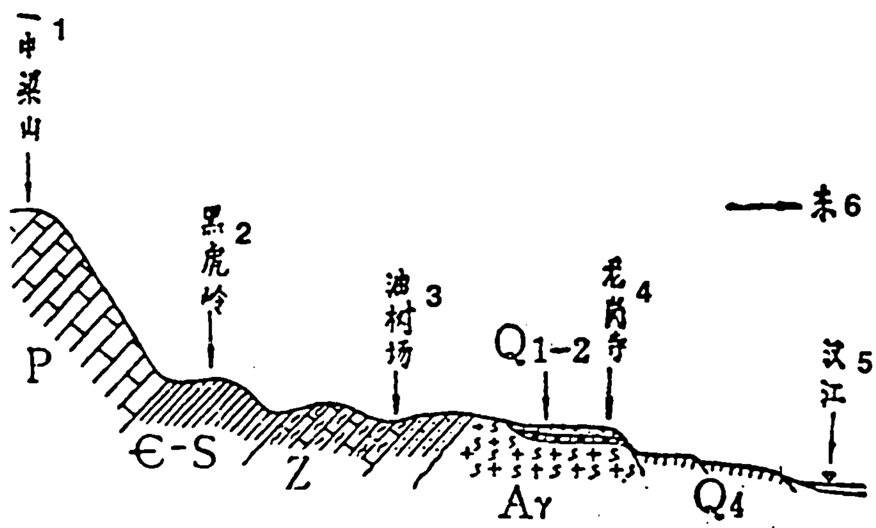


Fig. II 2. Geological map of the Hanshui River (Yan, 1980: Fig. 2). Key: 1. Middle Liangshan 2. Heihuling 3. Youshuchang 4. Longgangsi 5. Hanshui River 6. East

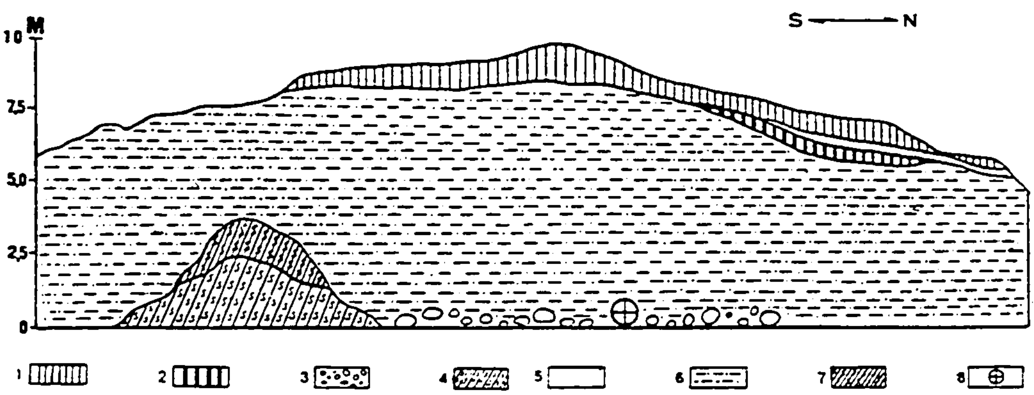


Fig. II 3. Section of brick kiln quarry, Longgangsi, Hanzhong (Huang, 1987: Fig. 2). Key: 1. Farming layer 2. Clay 3. Gravel 4. Bed rock 5. Fine sand 6. Sandy clay 7. Weathering bed rock 8. Stone artifacts

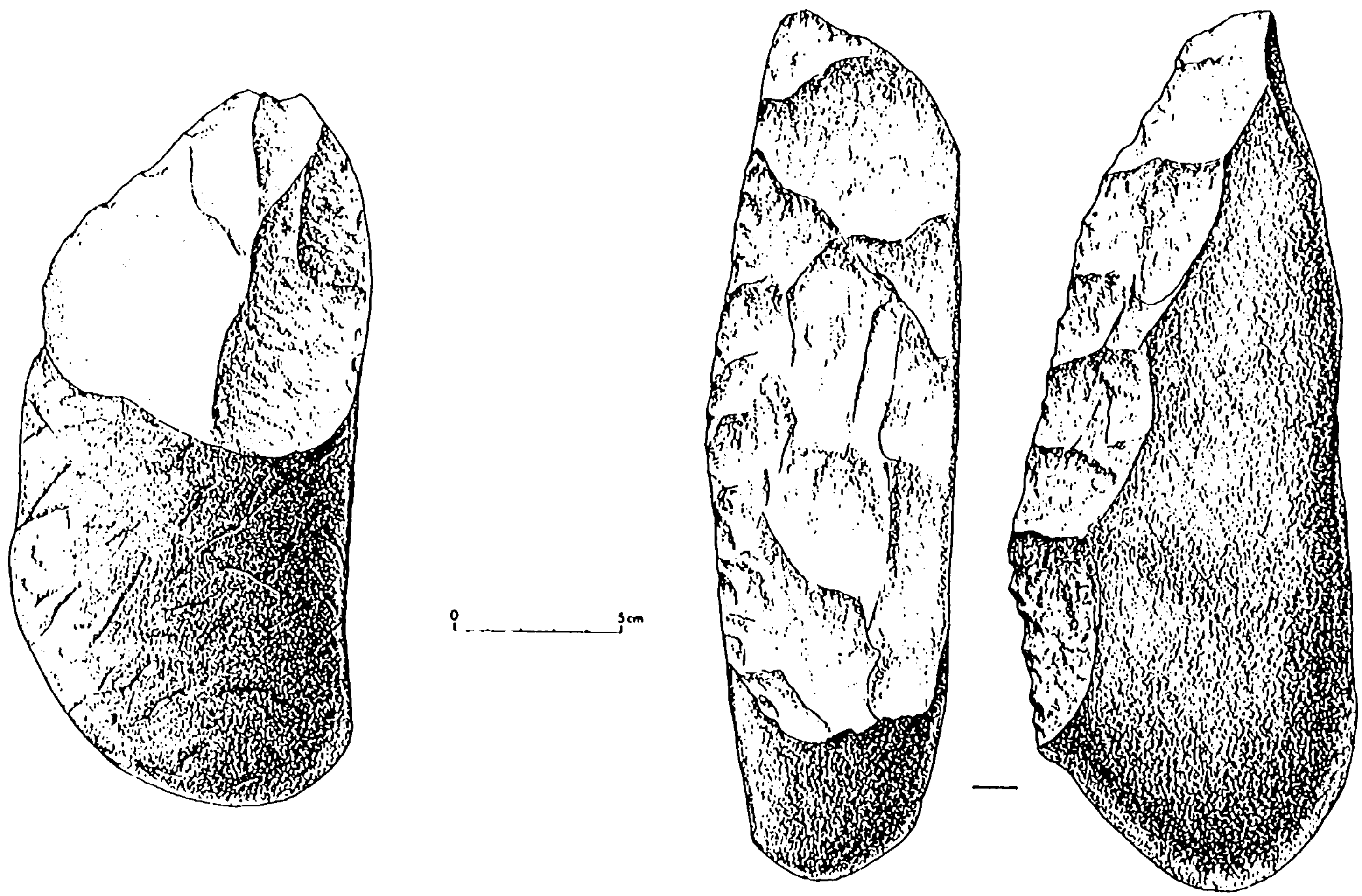


Fig. II 4. Tools of type Cl (1. P6293 2. Chitulin 2) from Liangshan.

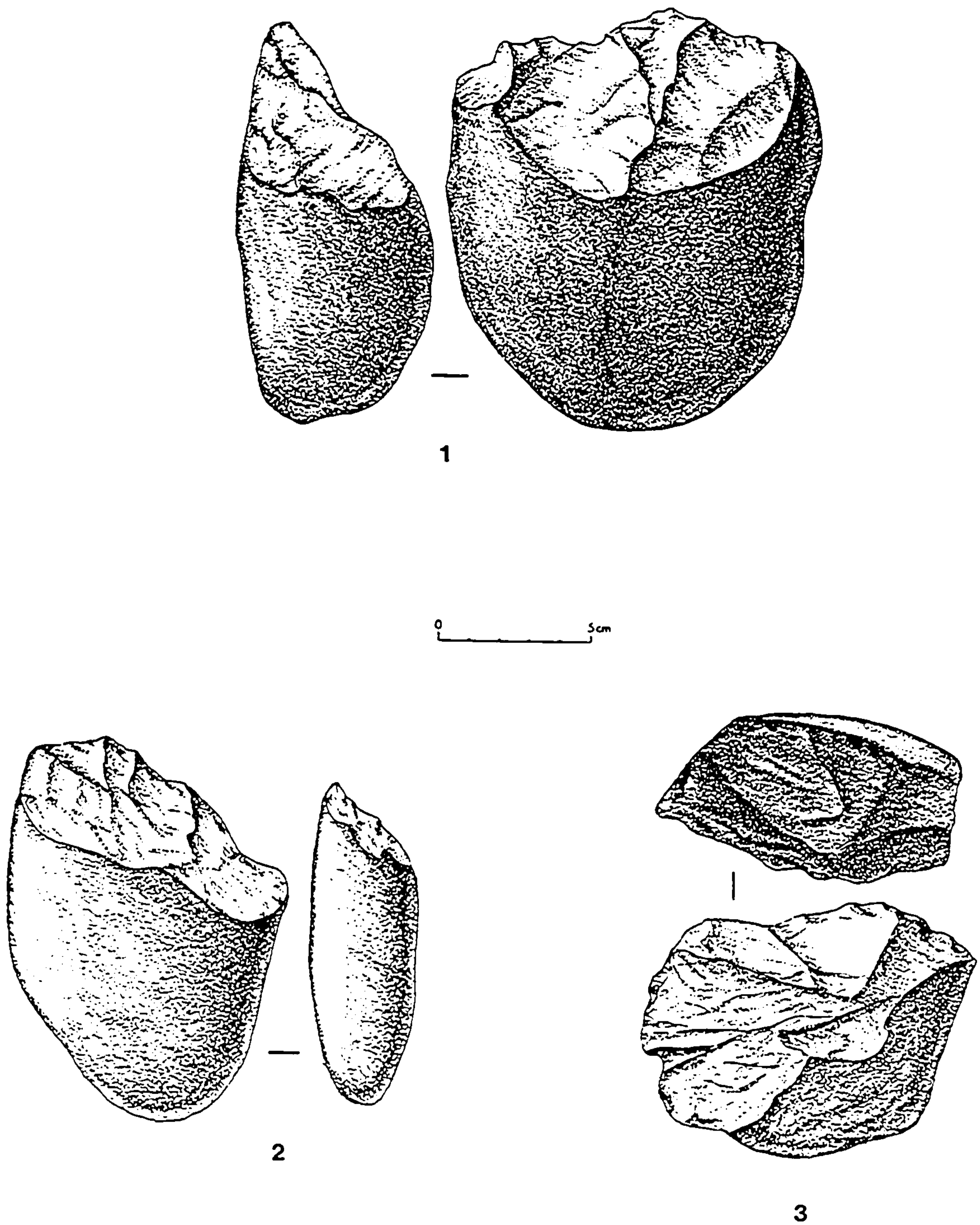


Fig. II 5. Tools of type Cl (1. P6307 2. P6303 3. P6300) from Liangshan.

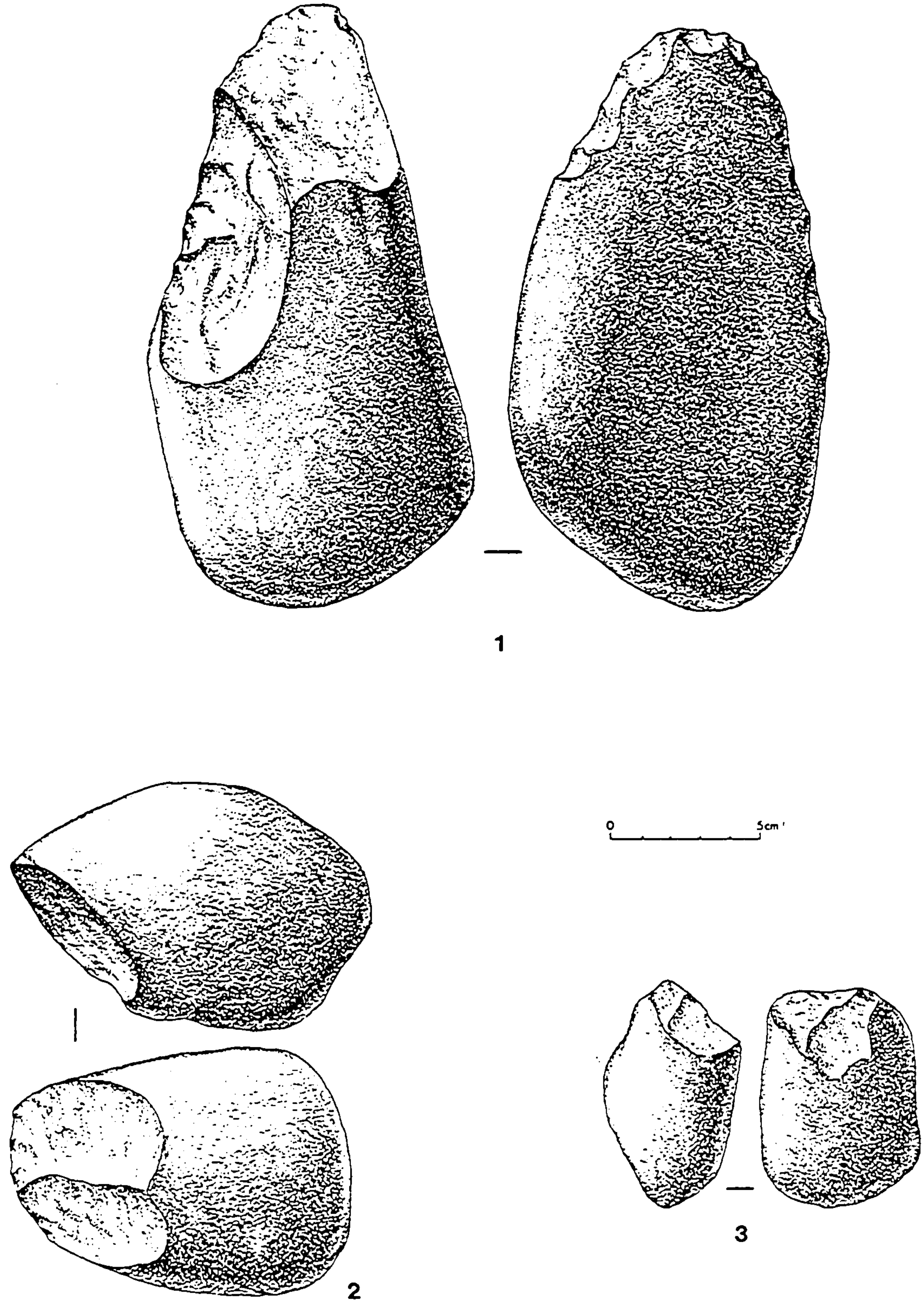


Fig. II 6. Tools of type Cl (1. SBP Chitulin 85004 2. P6250 3. P6253) from Liangshan.

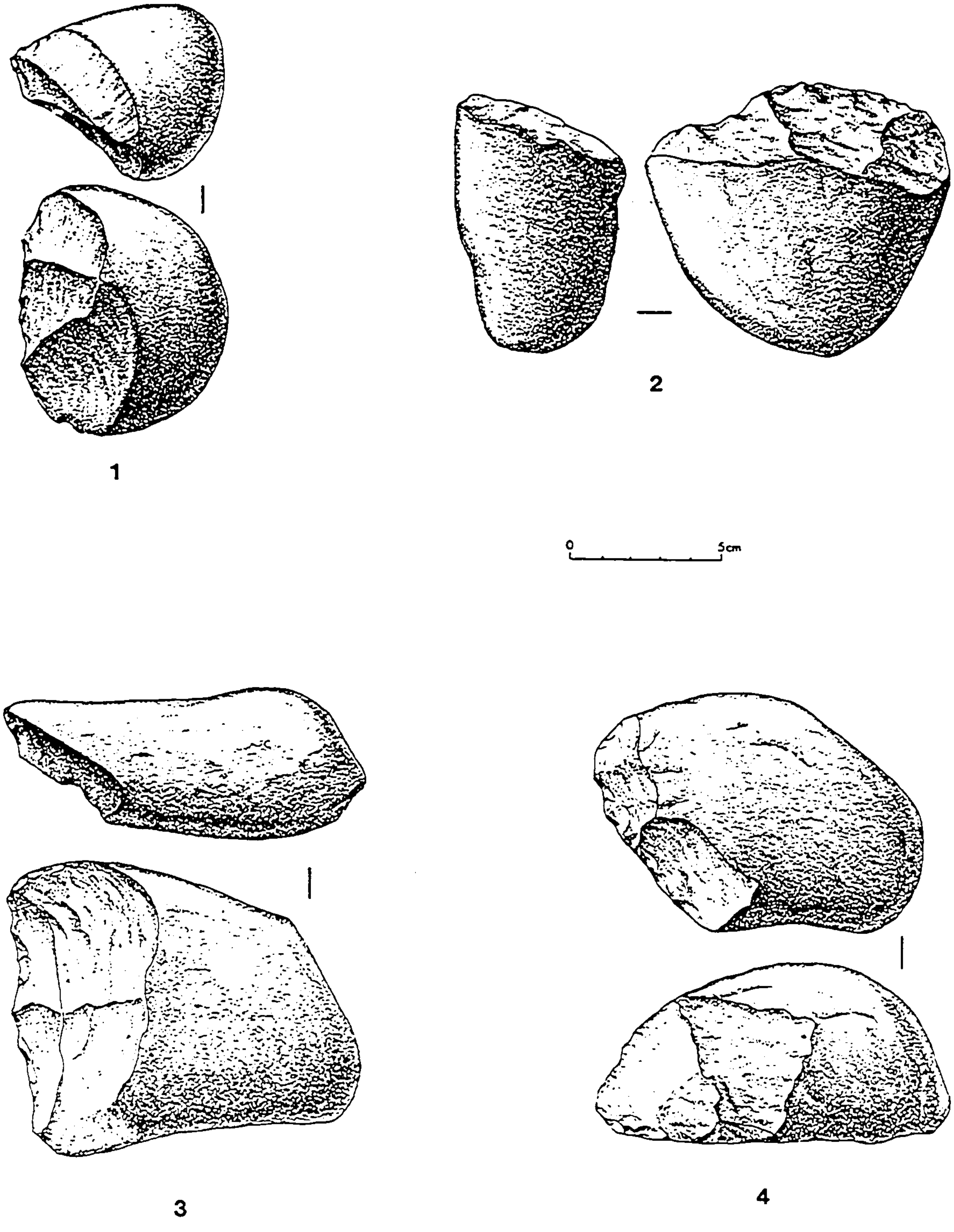


Fig. II 7. Tools of type Cl (1. P6269 2. P6304 3.P6267 4. P6287) from Liangshan.

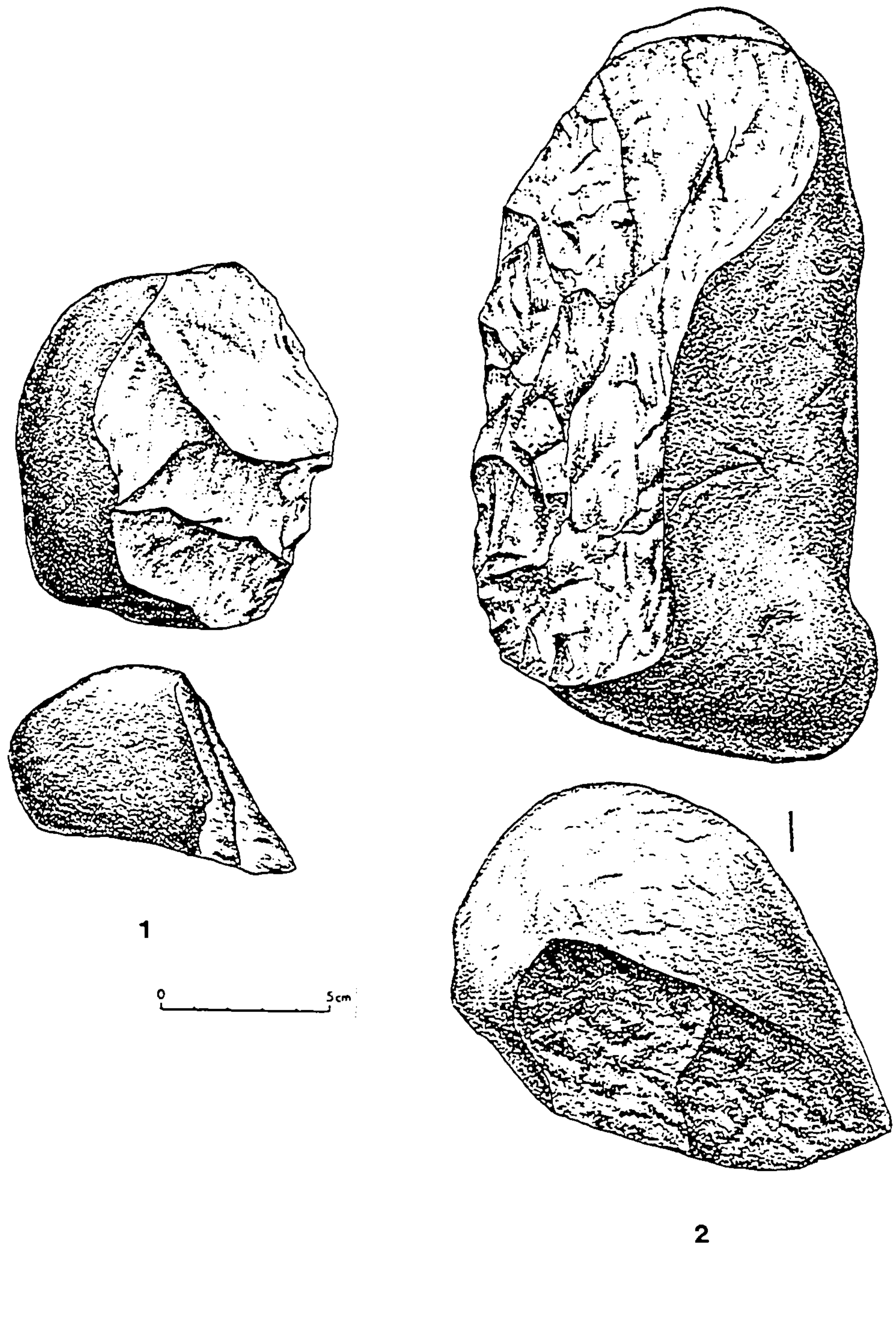


Fig. II 8. Tools of type Cl (1. P6262 2. P6292) from Liangshan.

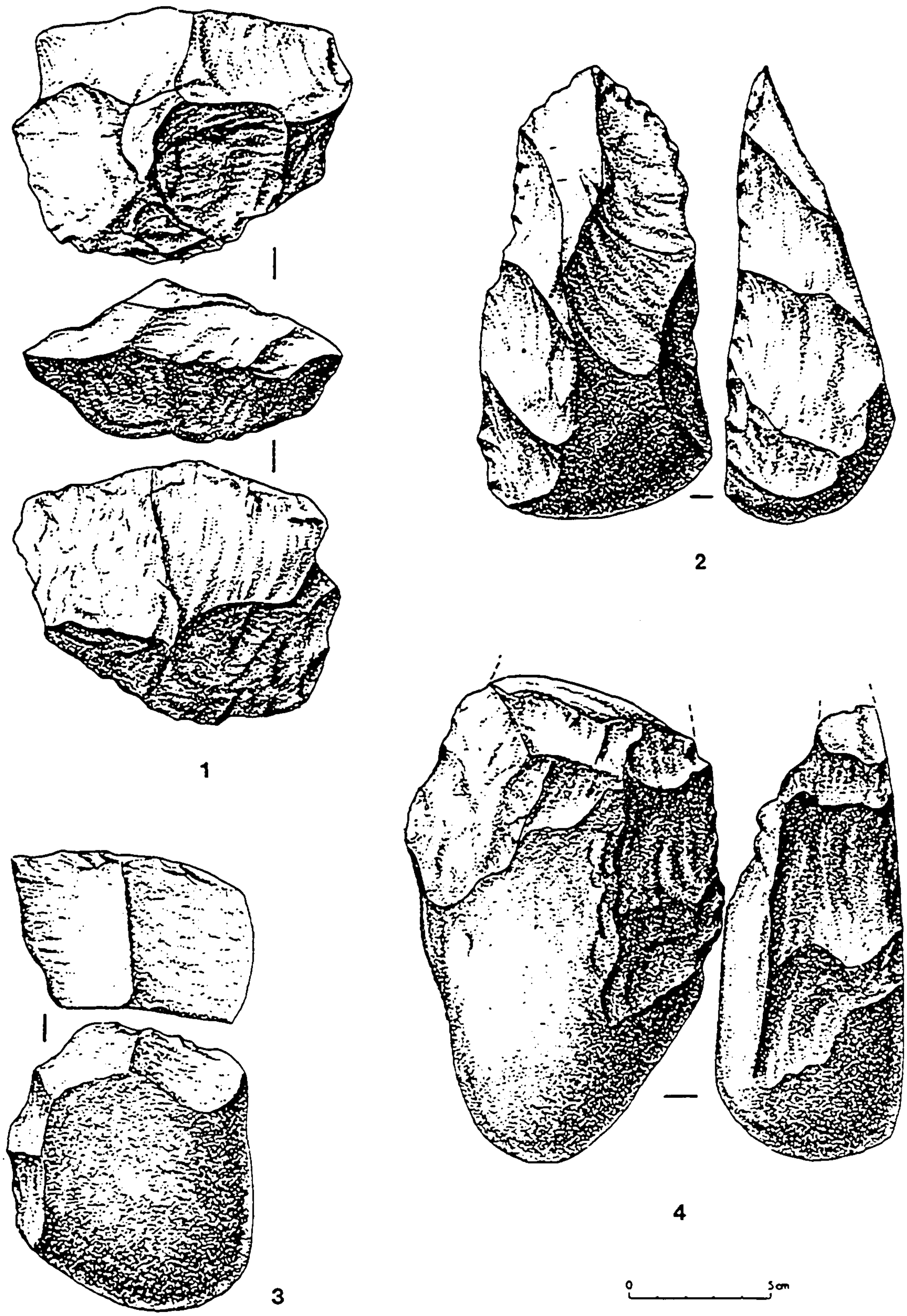


Fig. II 9. Tools of type C2 (1. P6311 2. P6210 3. Liangshan 85.11 4. P6302) from Liangshan.

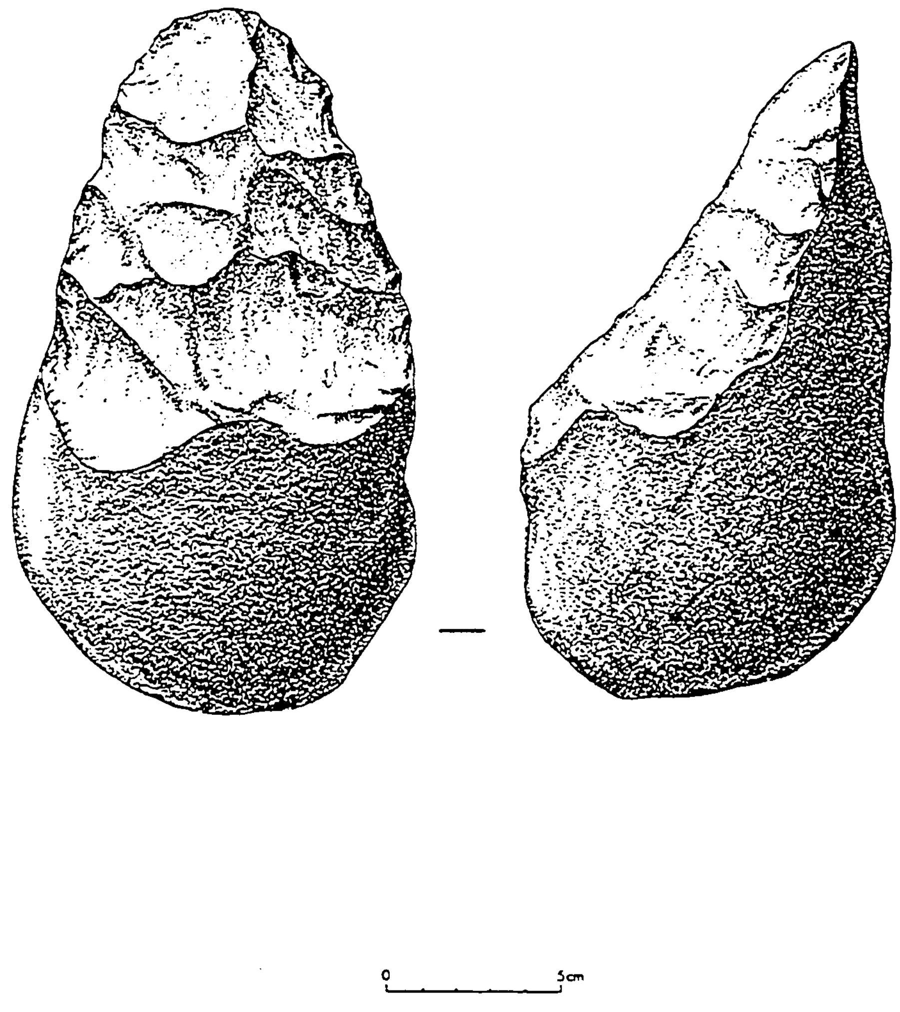


Fig. II 10. Tool of type C5 (Chitulin 3) from Liangshan.

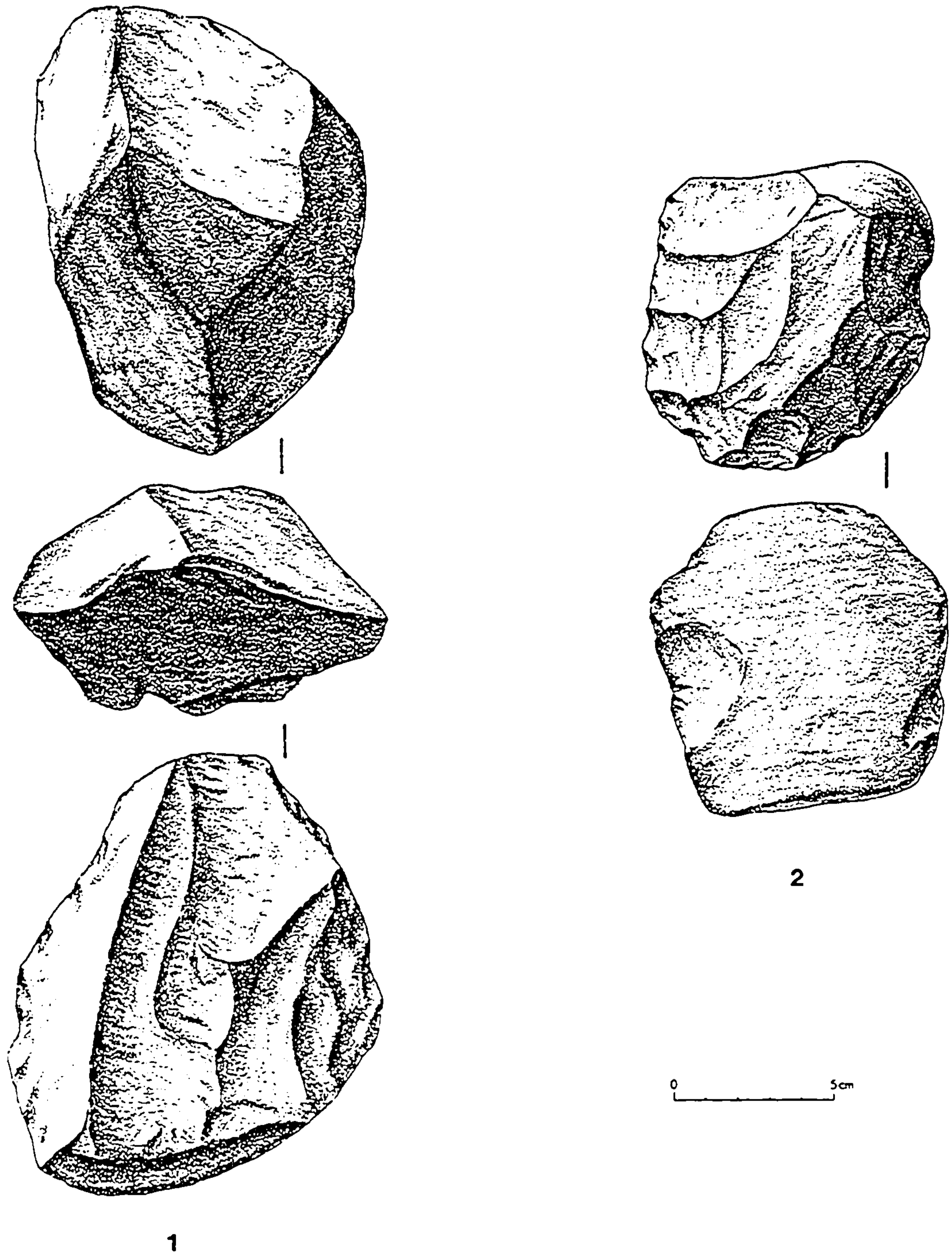


Fig. II 11. Tools of type C7 (1. Liangshan 85.14 2. P6214) from Liangshan.

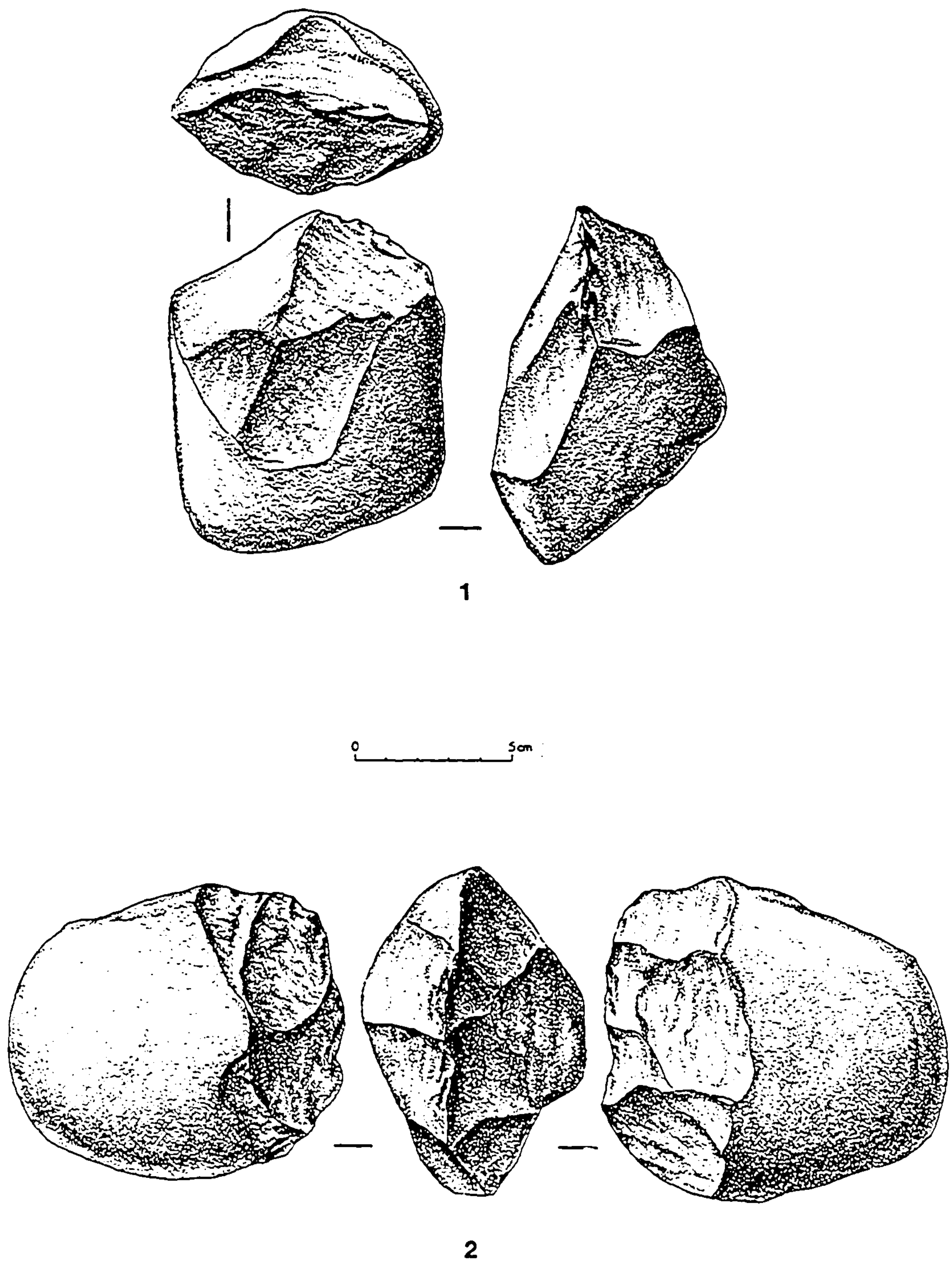


Fig. II 12. Tools of type C9 (1. P6305 2. P6260) from Liangshan.

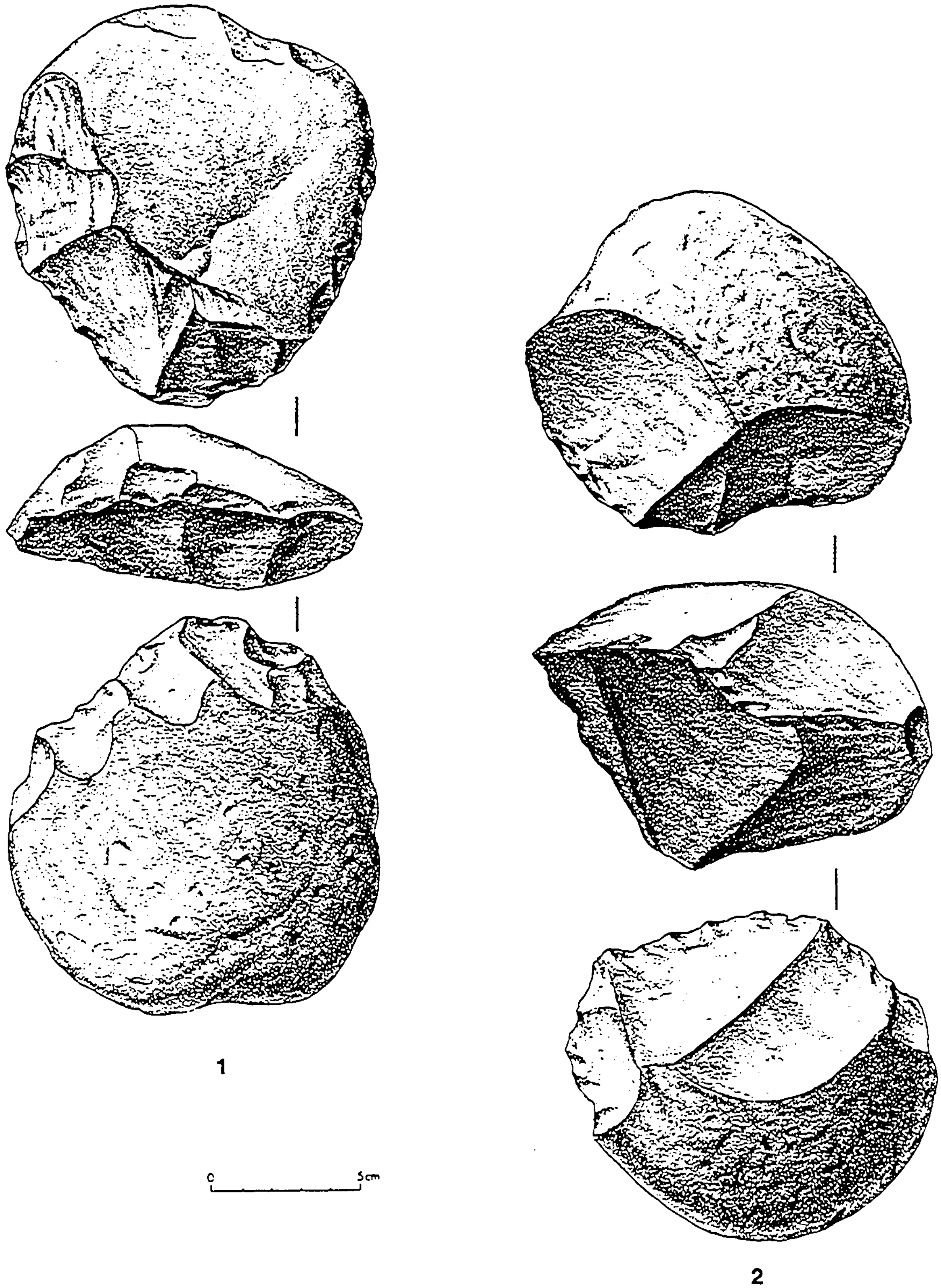


Fig. II 13. Tools of type C9 (1. P6217 2. P6227) from Liangshan.

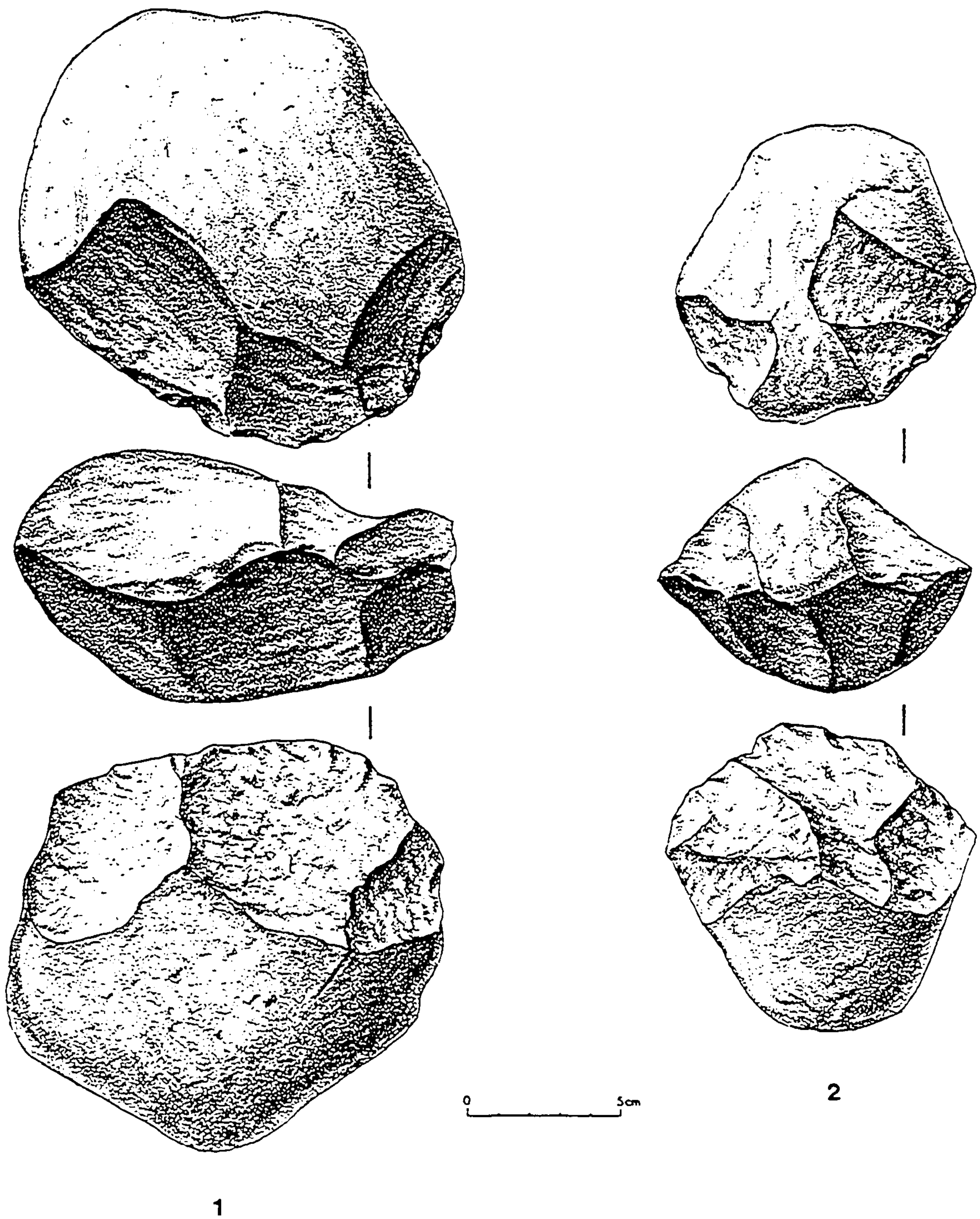


Fig. II 14. Tools of type C9 (1. P6266 2. P6258) from Liangshan

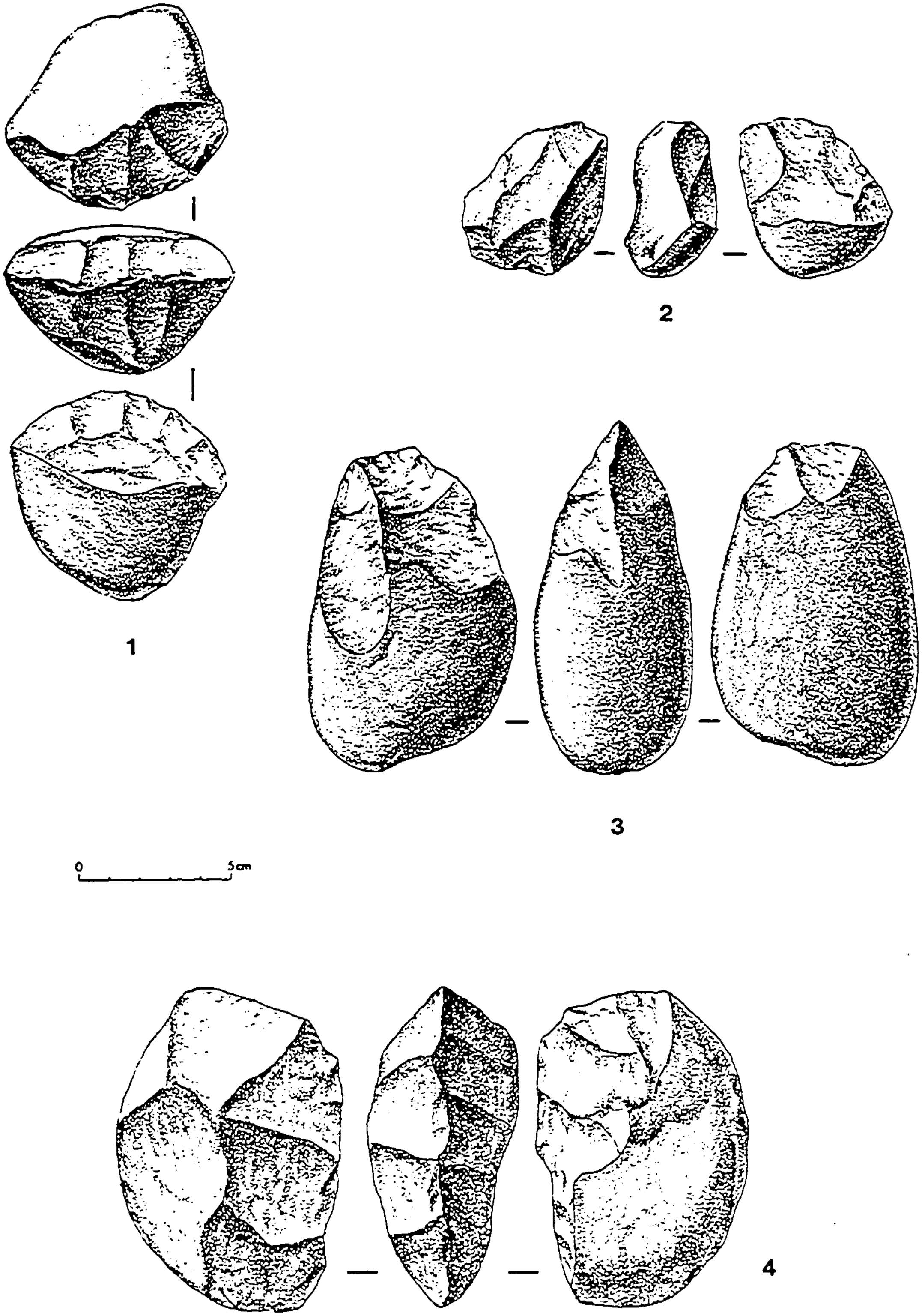


Fig. II 15. Tools of type C9 (1. P6221 2. P6286 3. P6225 4. P6224) from Liangshan.

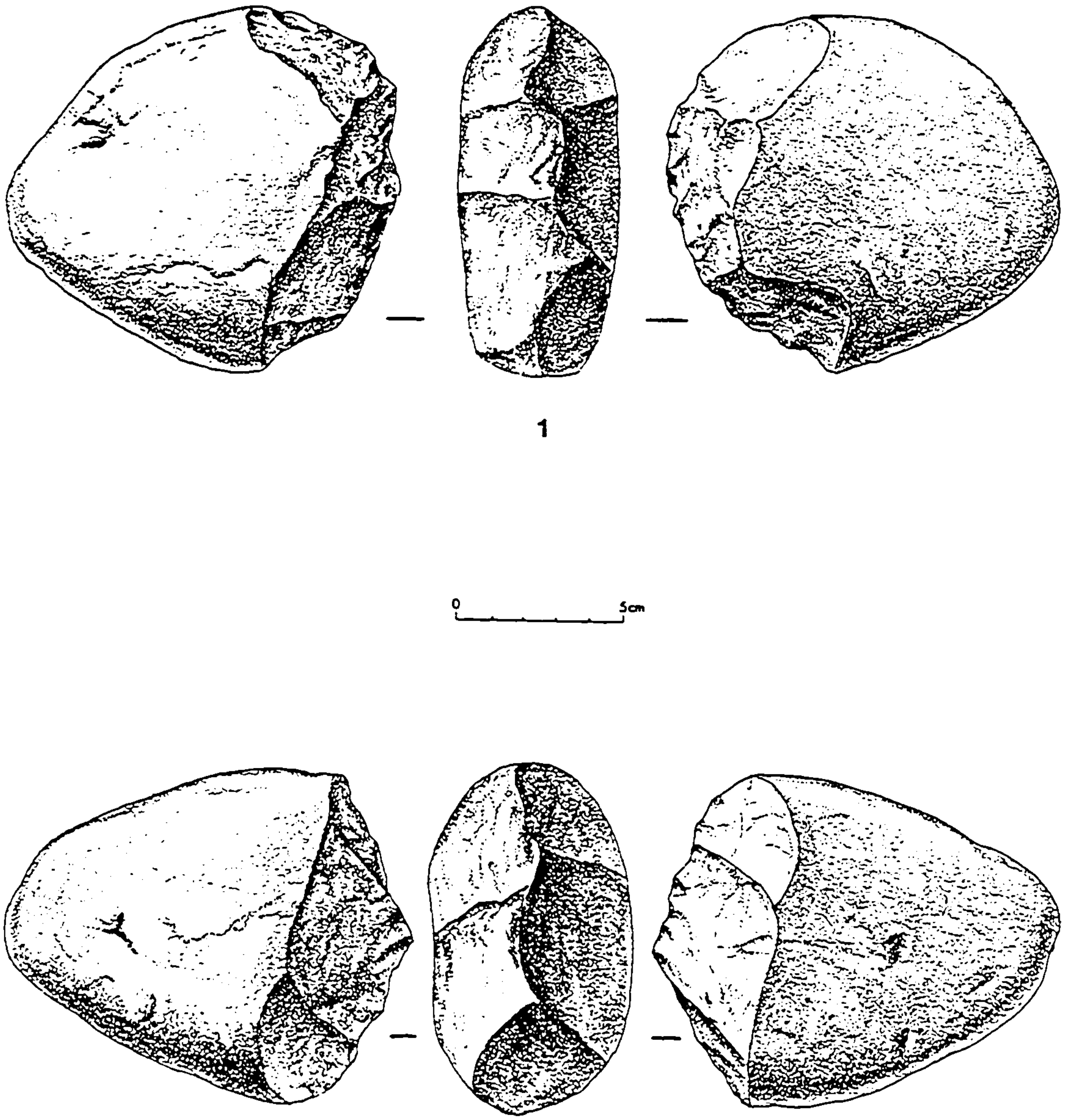


Fig. II 16. Tools of type C9 (1. P6213 2. P6259) from Liangshan.

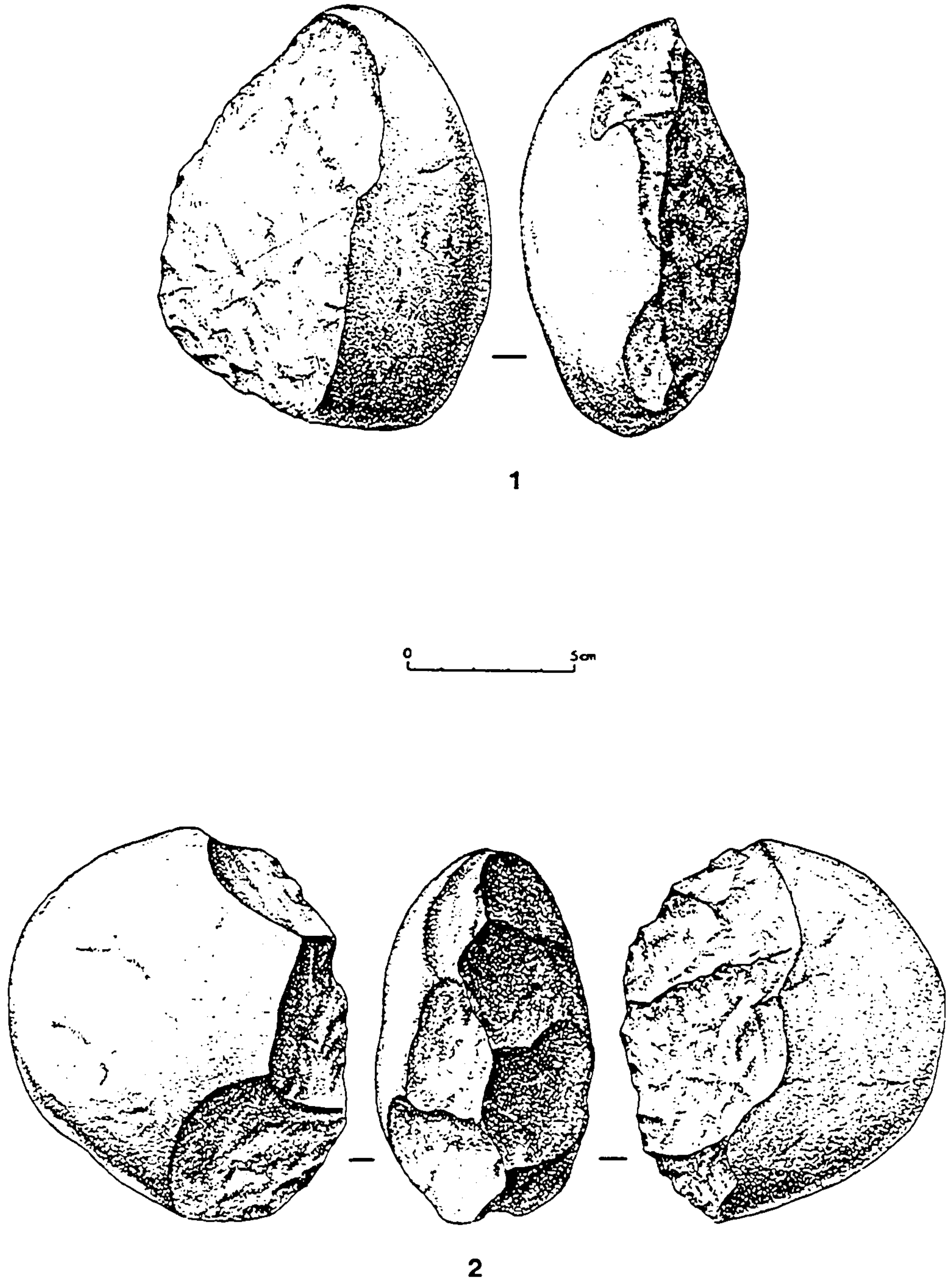


Fig. II 17. Tools of type C9 (1. P6265 2. P6295) from Liangshan.

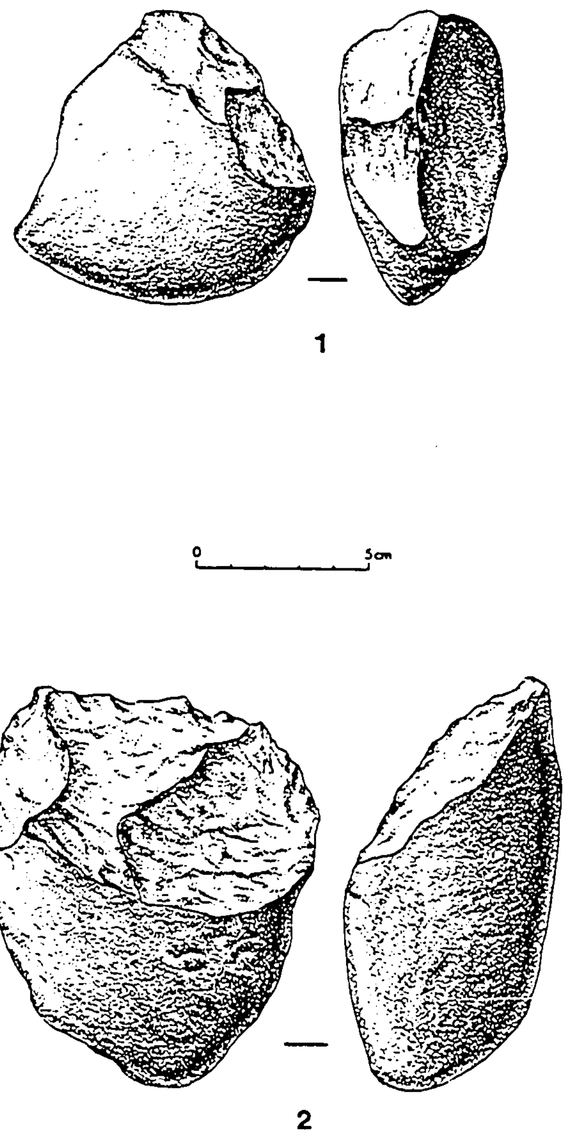


Fig. II 18. Tools of type C9 (1. P6261 2. P6264) Liangshan.

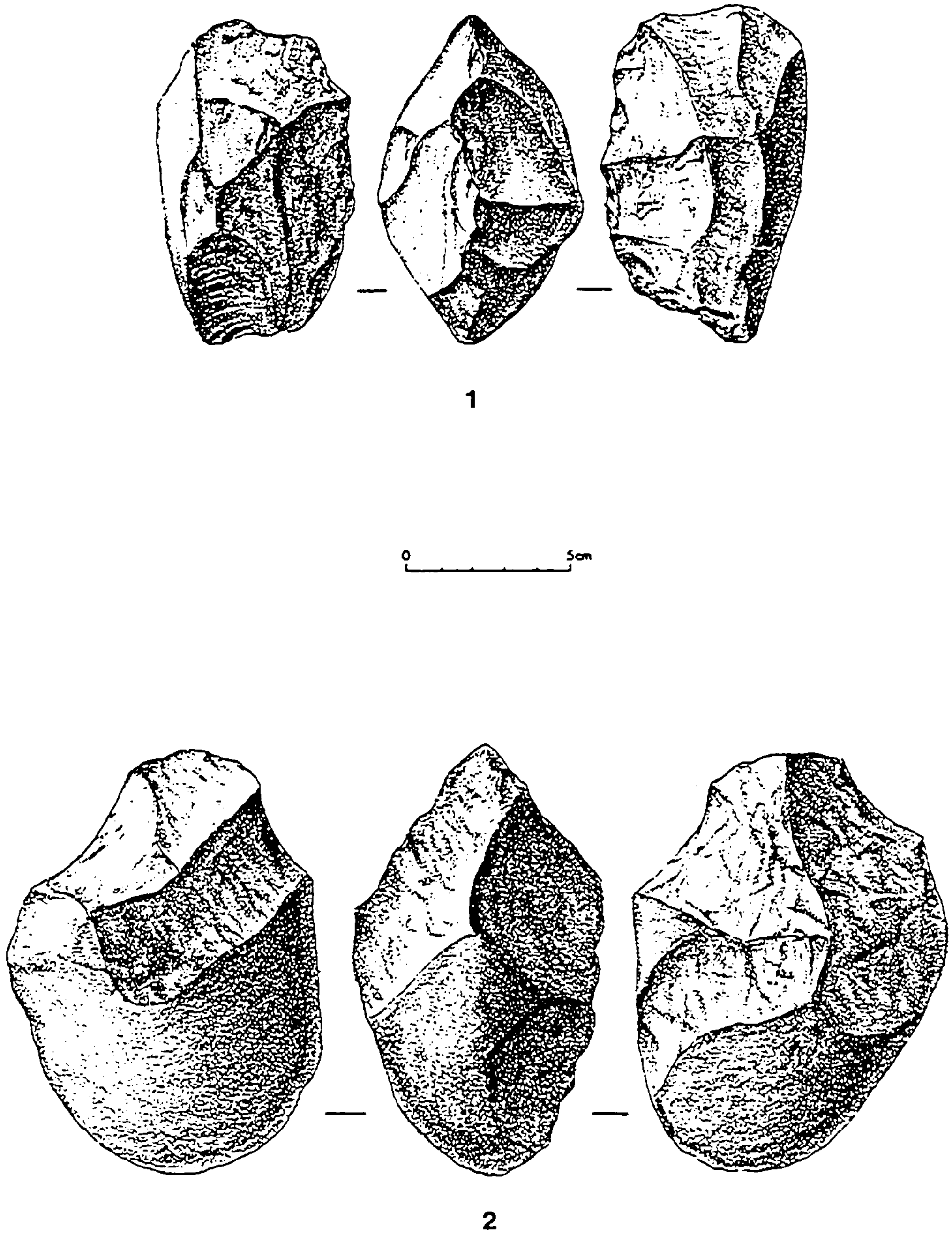


Fig. II 19. Tools of type C11 (1. P6222) and C13 (2. SBP Chitulin 85002) from Liangshan.

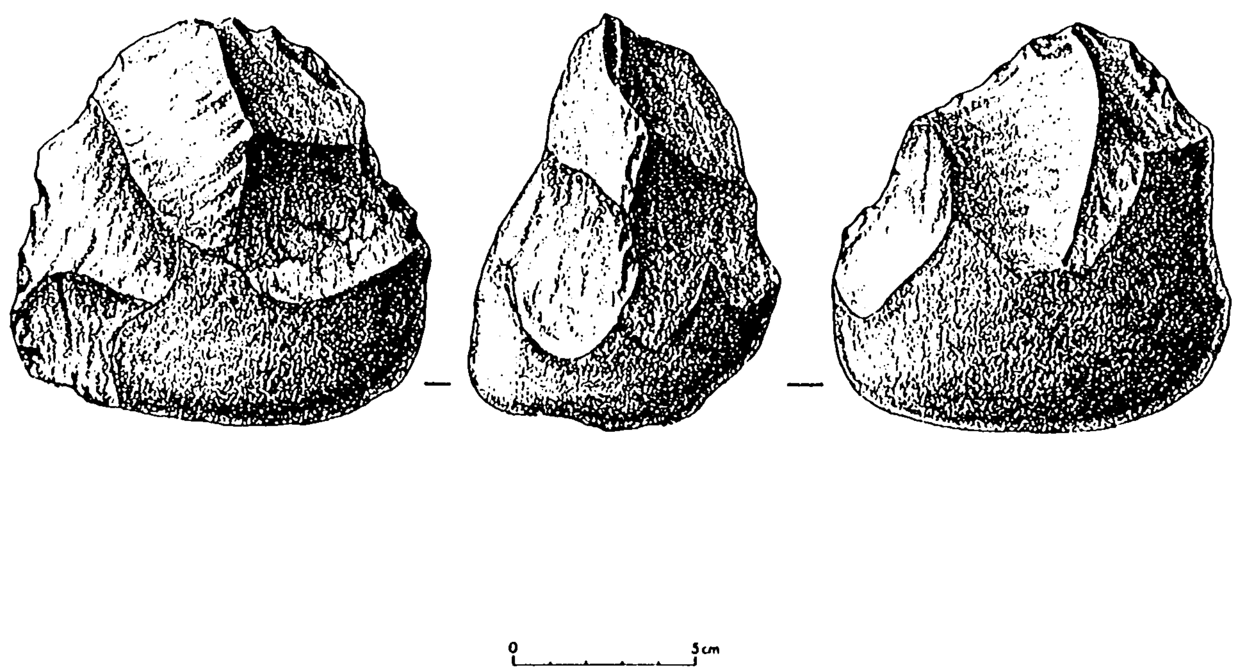


Fig. II 20. Tool of type C13 (P6313) from Liangshan.

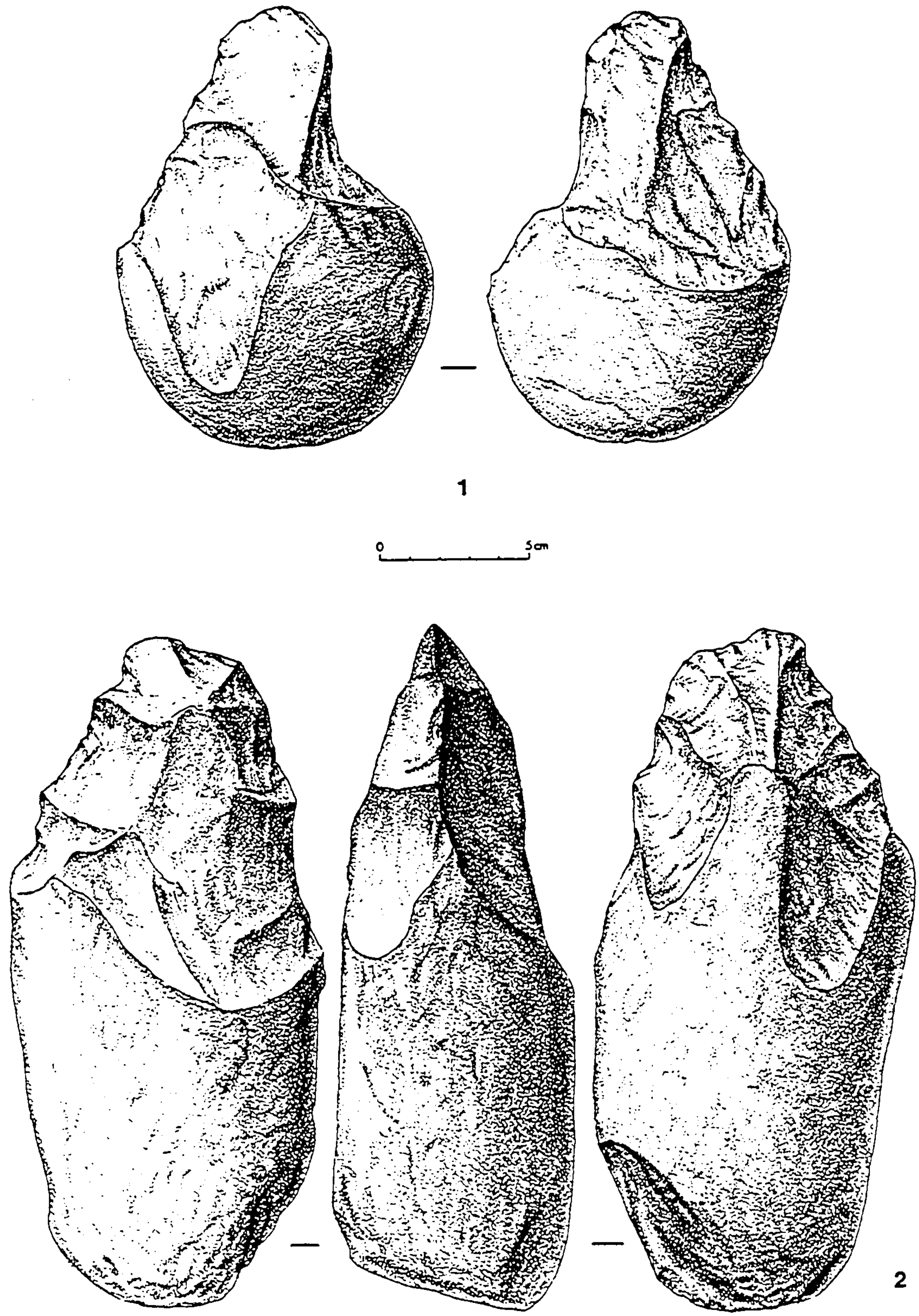


Fig. II 21. Tools of type C13 (1. 85 Nanzhen 003 2. 86 Mianyuan 004) from Liangshan.

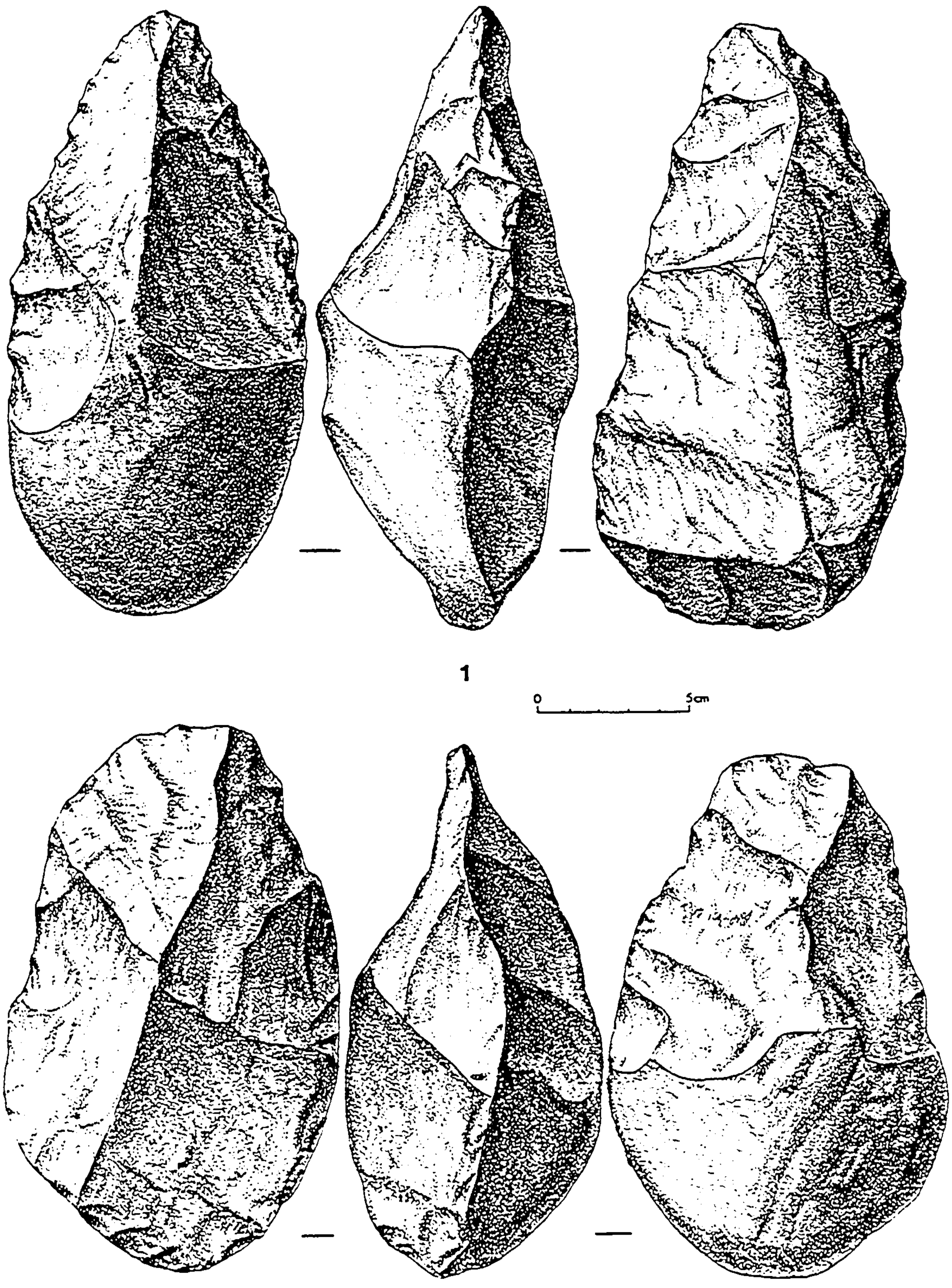


Fig. II 22. Tools of type C13 (1. Liangshan 0005 2. Mianxian 002) from Liangshan.

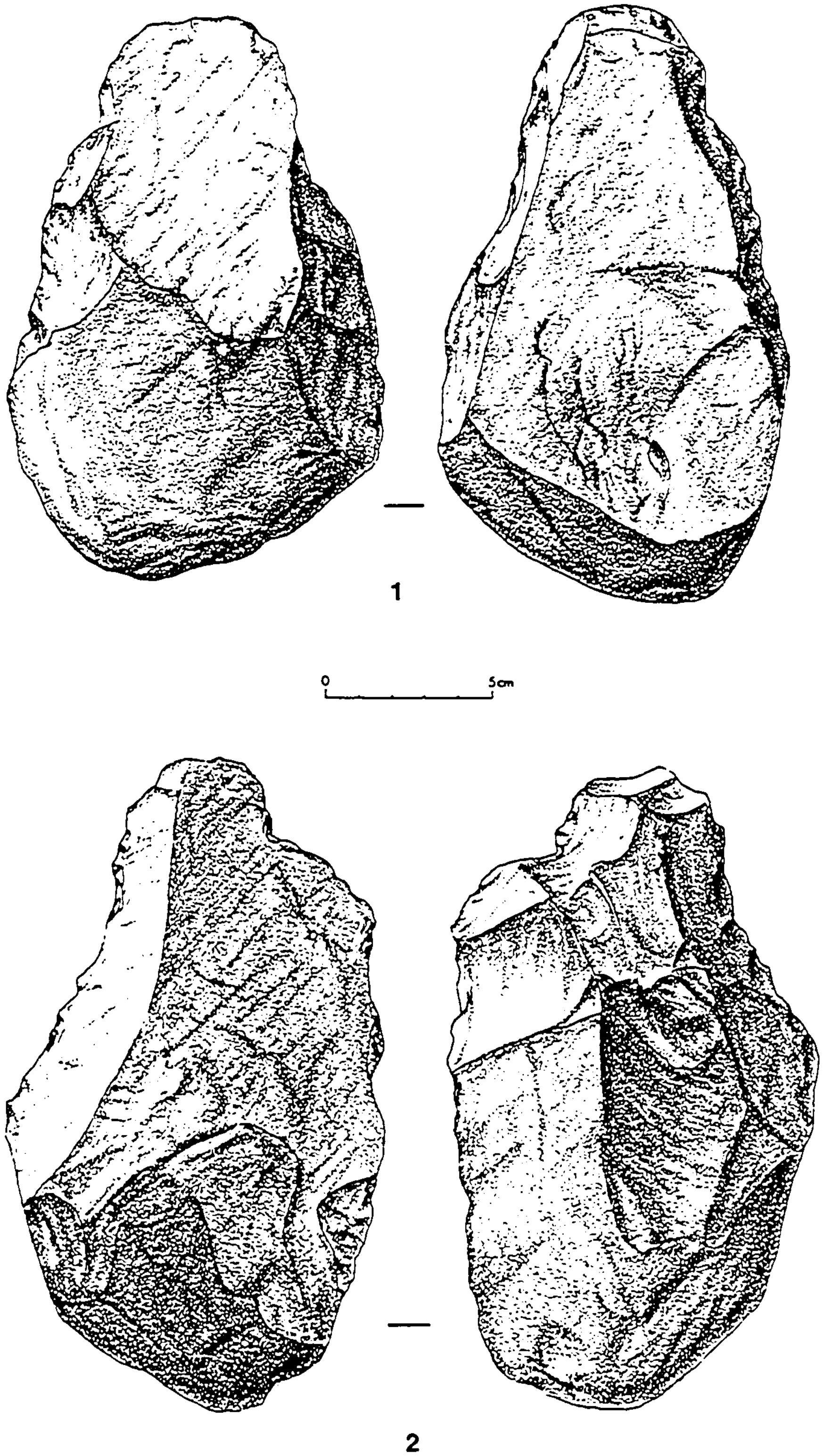


Fig. II 23. Tools of type C13 (1. Nanlongyou 002 2. 86 Mianyuan 014) from Liangshan.

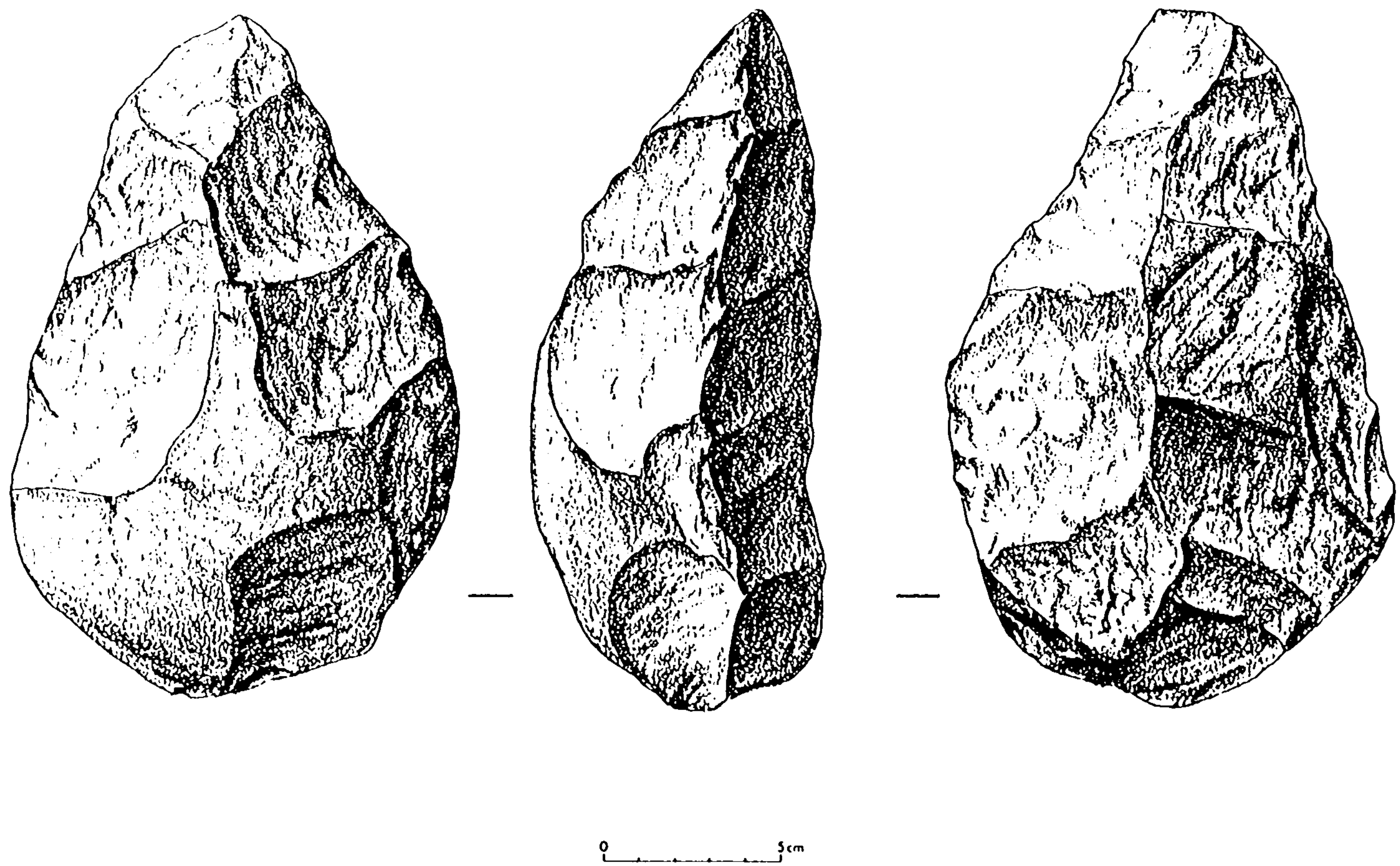


Fig. II 24. Tool of type C13 (86 Mianyuan 005) from Liangshan.

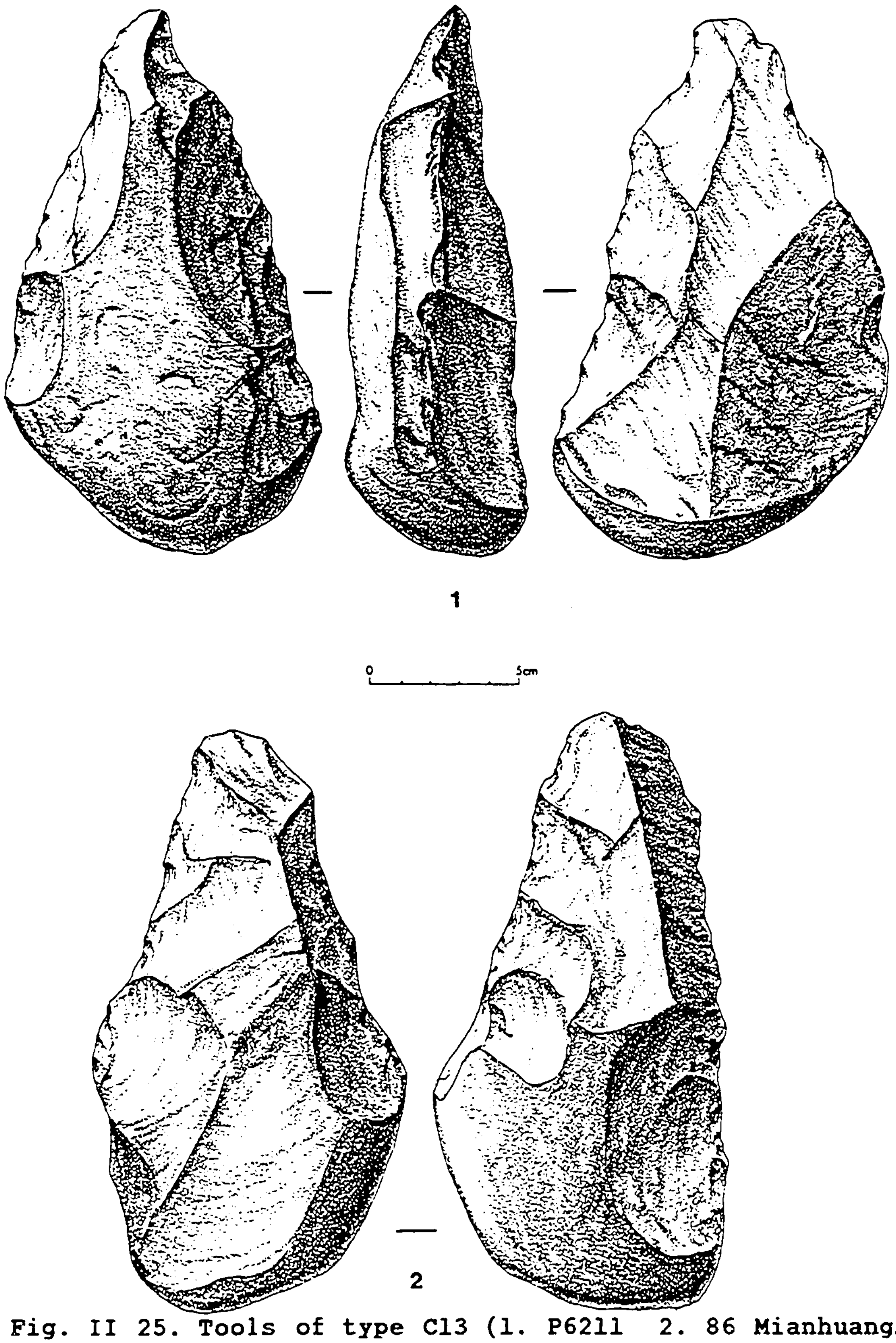


Fig. II 25. Tools of type C13 (1. P6211 2. 86 Mianhuangsha 001) from Liangshan.

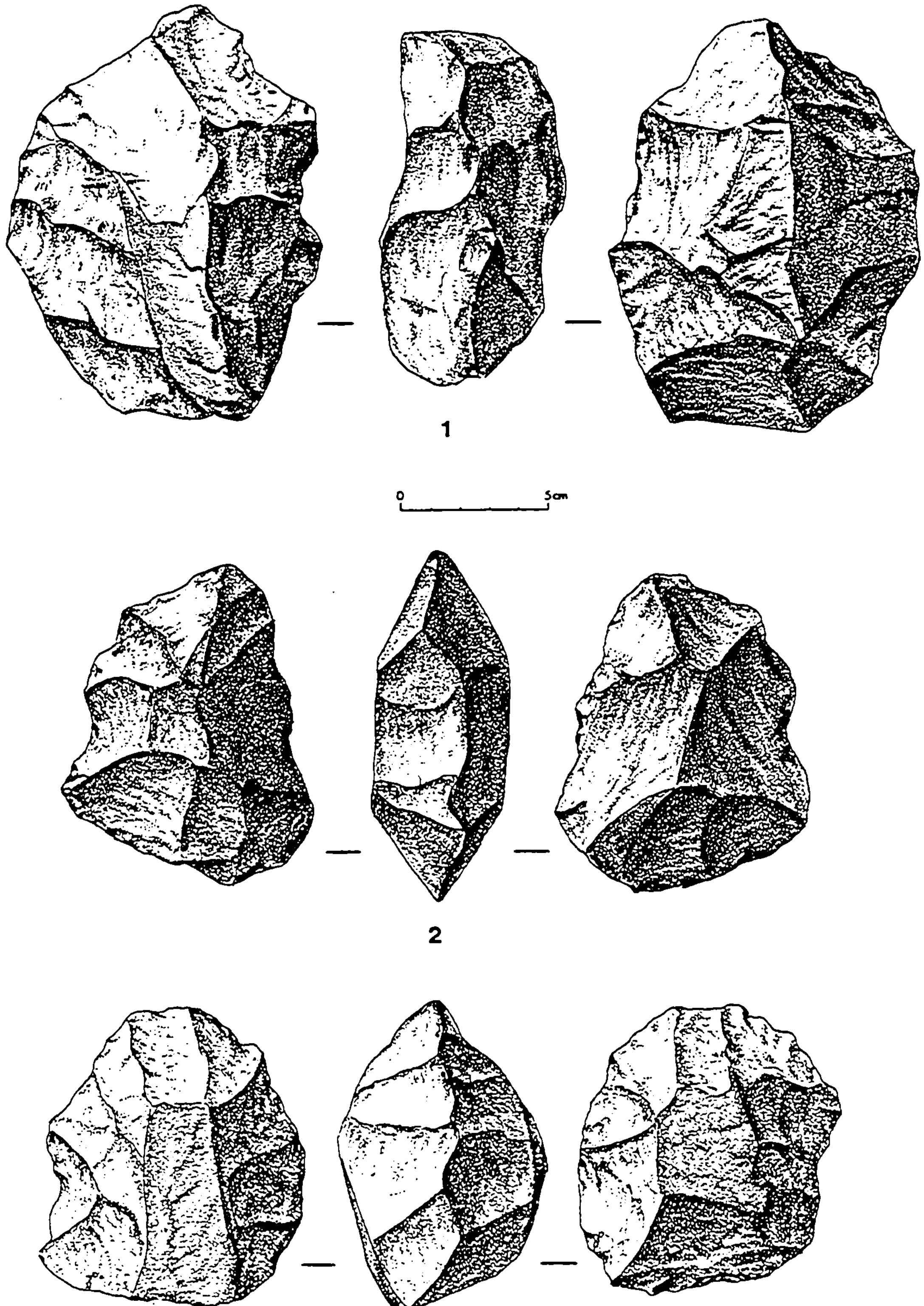


Fig. II 26. Tools of type C15 (1. P6312 2. P6289 3. P6218) from Liangshan.

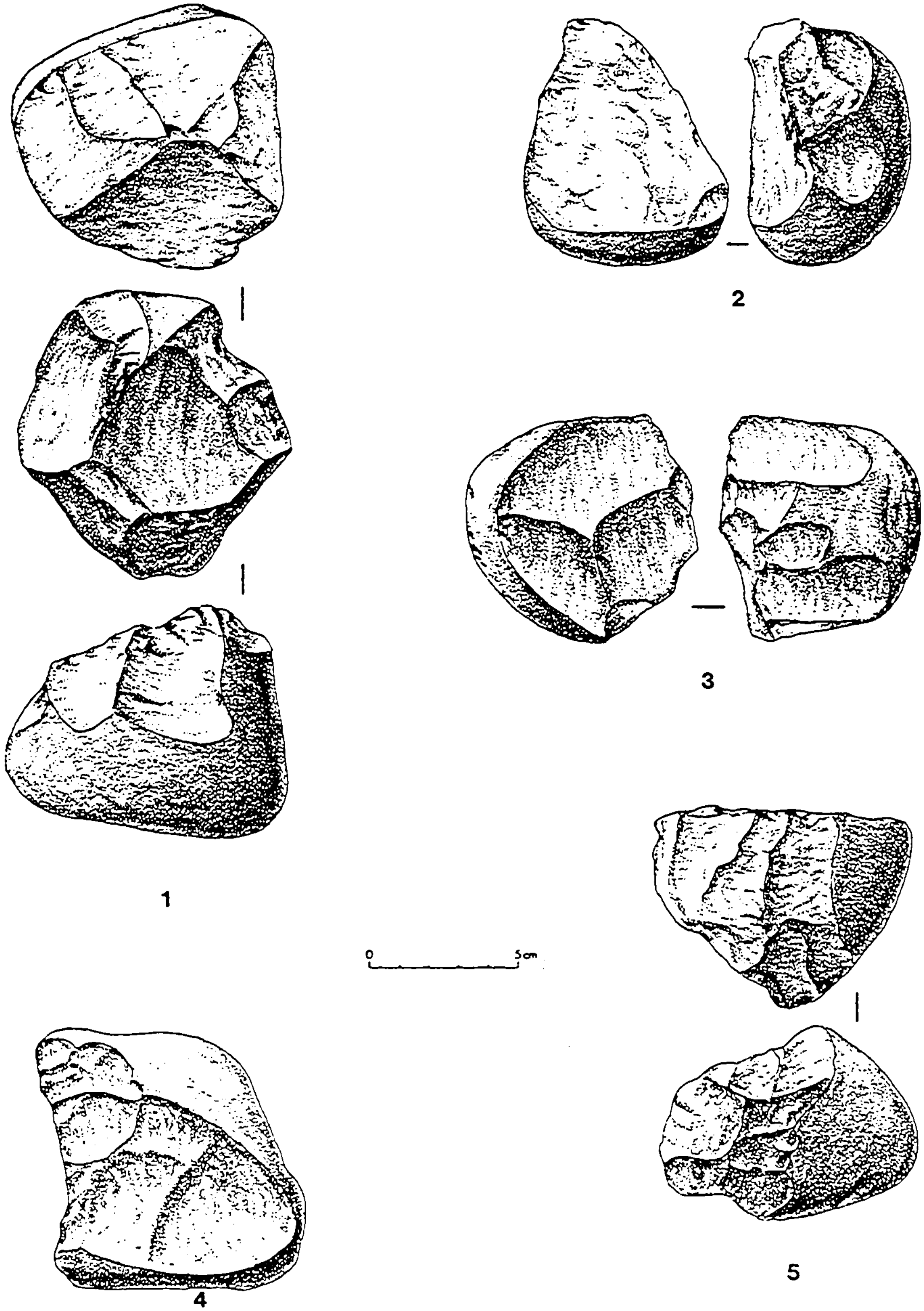


Fig. II 27. Tools of type C17 (1. P6289 2. P6220 3. P6208 4. P6232 5. Liangshan 85.1) from Liangshan.

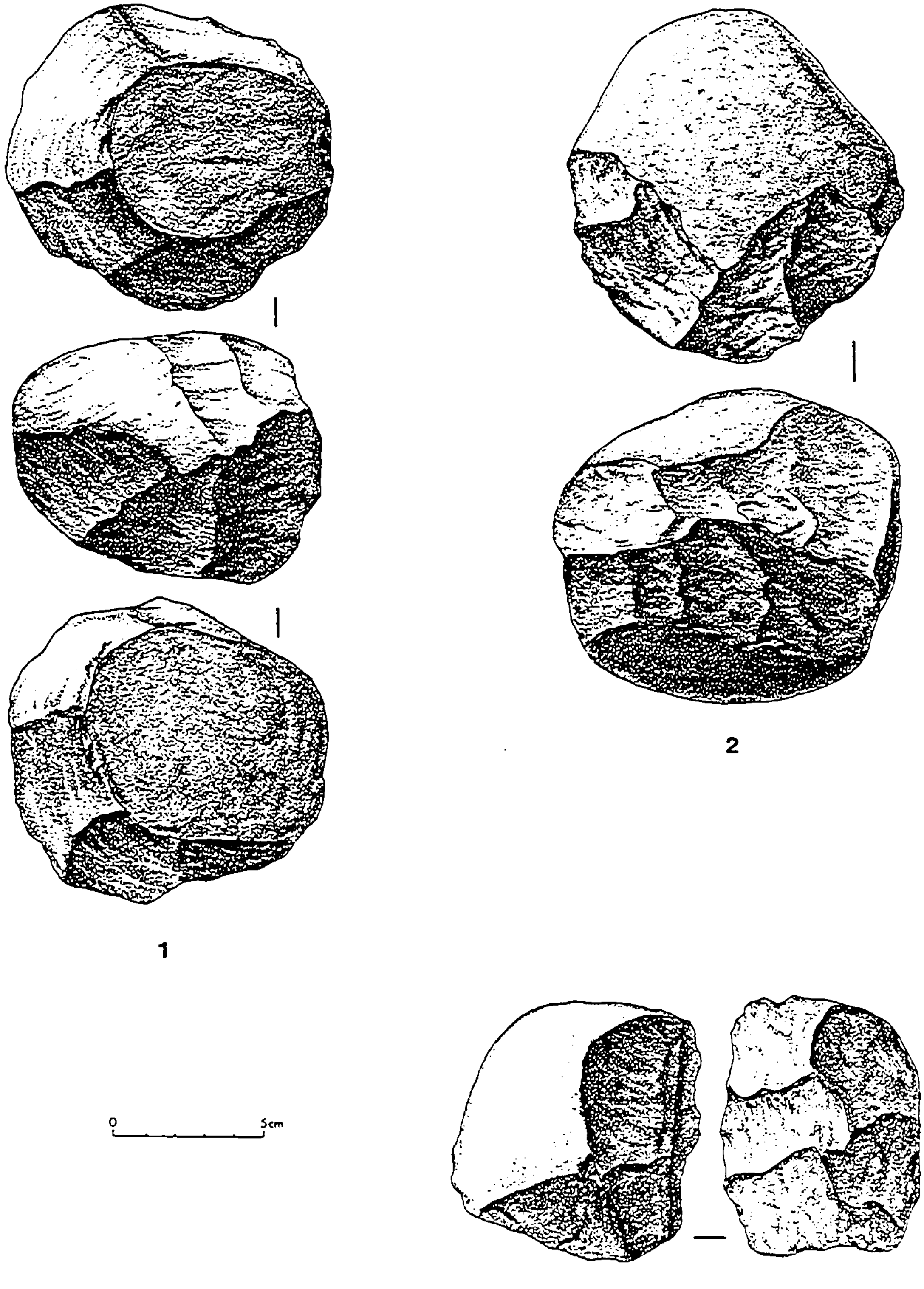


Fig. II 28. Tools of type C17 (1. P6299 2. Chitulin 1 3. Liangshan 85.2) from Liangshan.

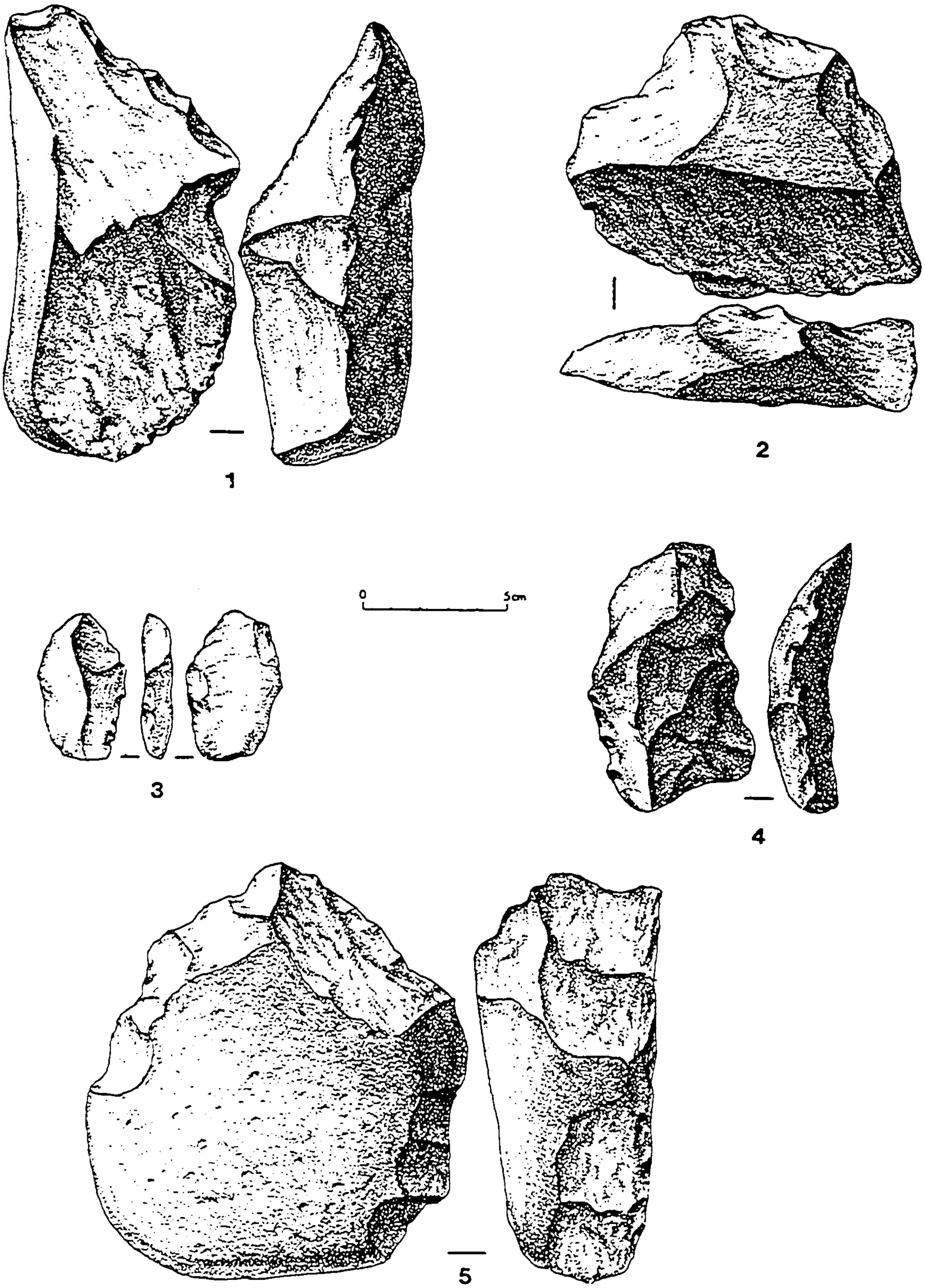


Fig. II 29. Tools of type F1 (1. Liangshan 85.19 2. P6301), F2 (3. P6243 4. P6277) and F5 (5. P6257) from Liangshan.

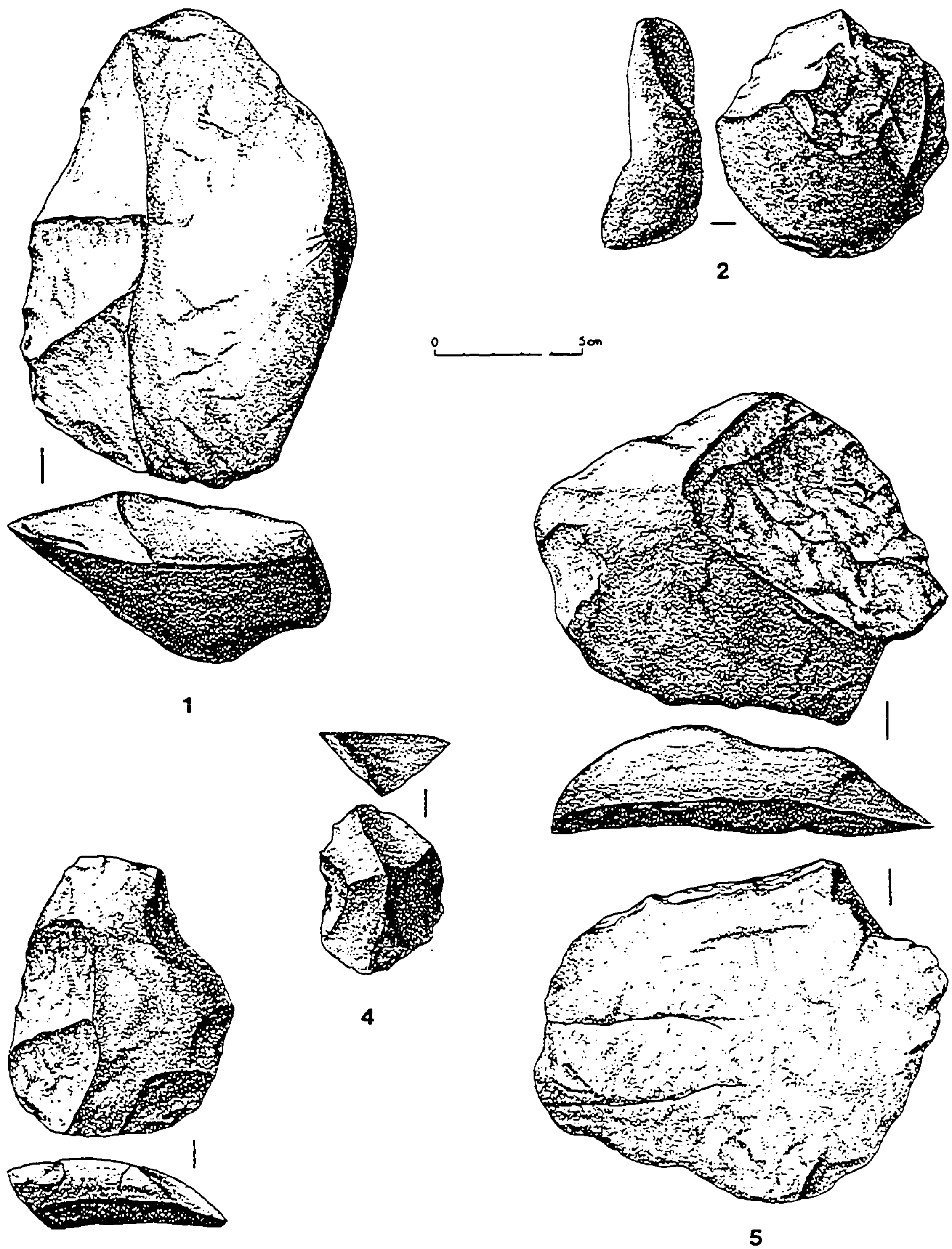


Fig. II 30. Tools of type F7 (1. ND 008), F8 (2. P6275), and F9 (3. Liangshan 85.6 4. Liangshan 85.8 5. P6246) from Liangshan.

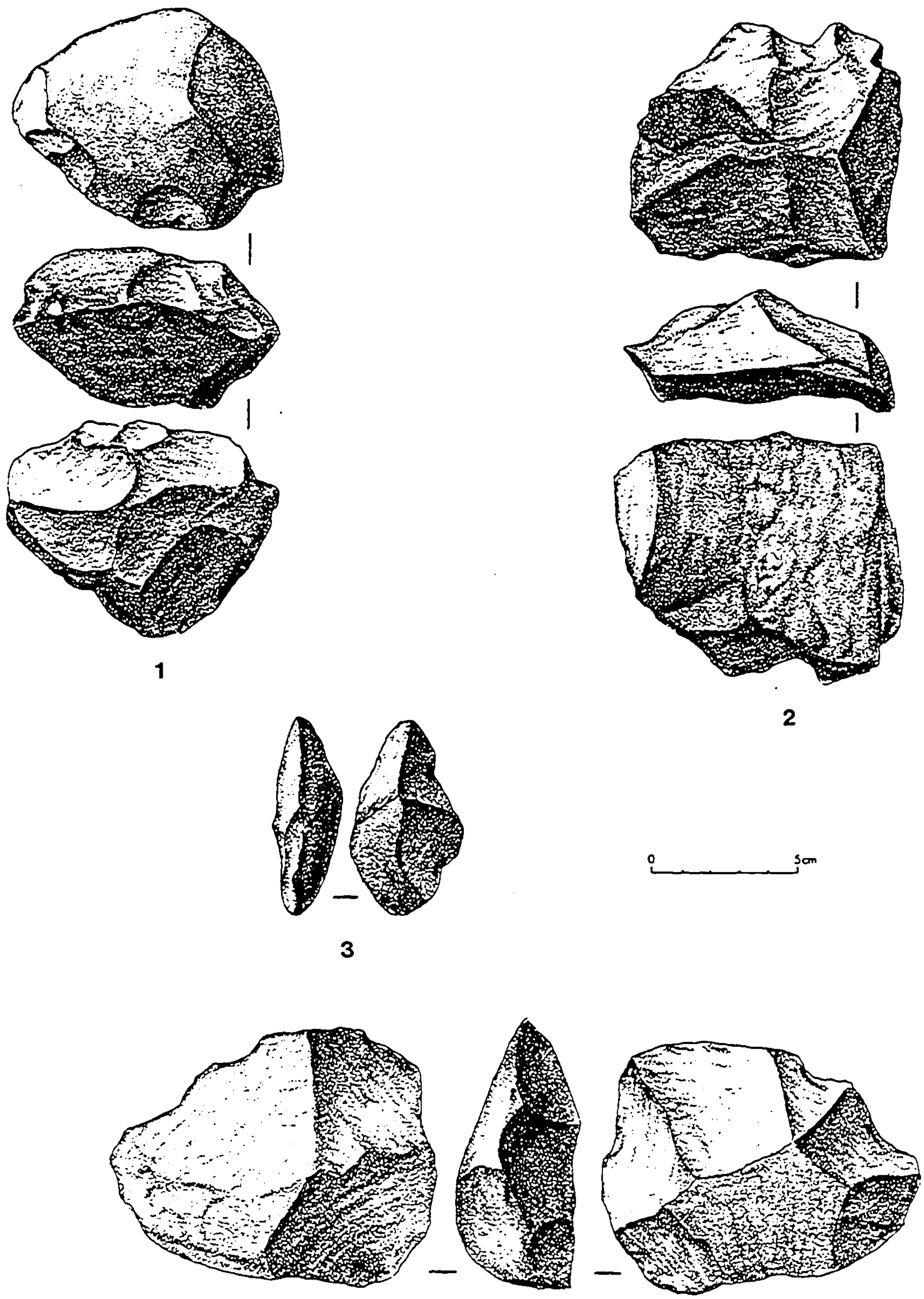


Fig. II 31. Tools of type F12 (1. P6274 2. Liangshan 85.10 3. P6281 4. P6215) from Liangshan.

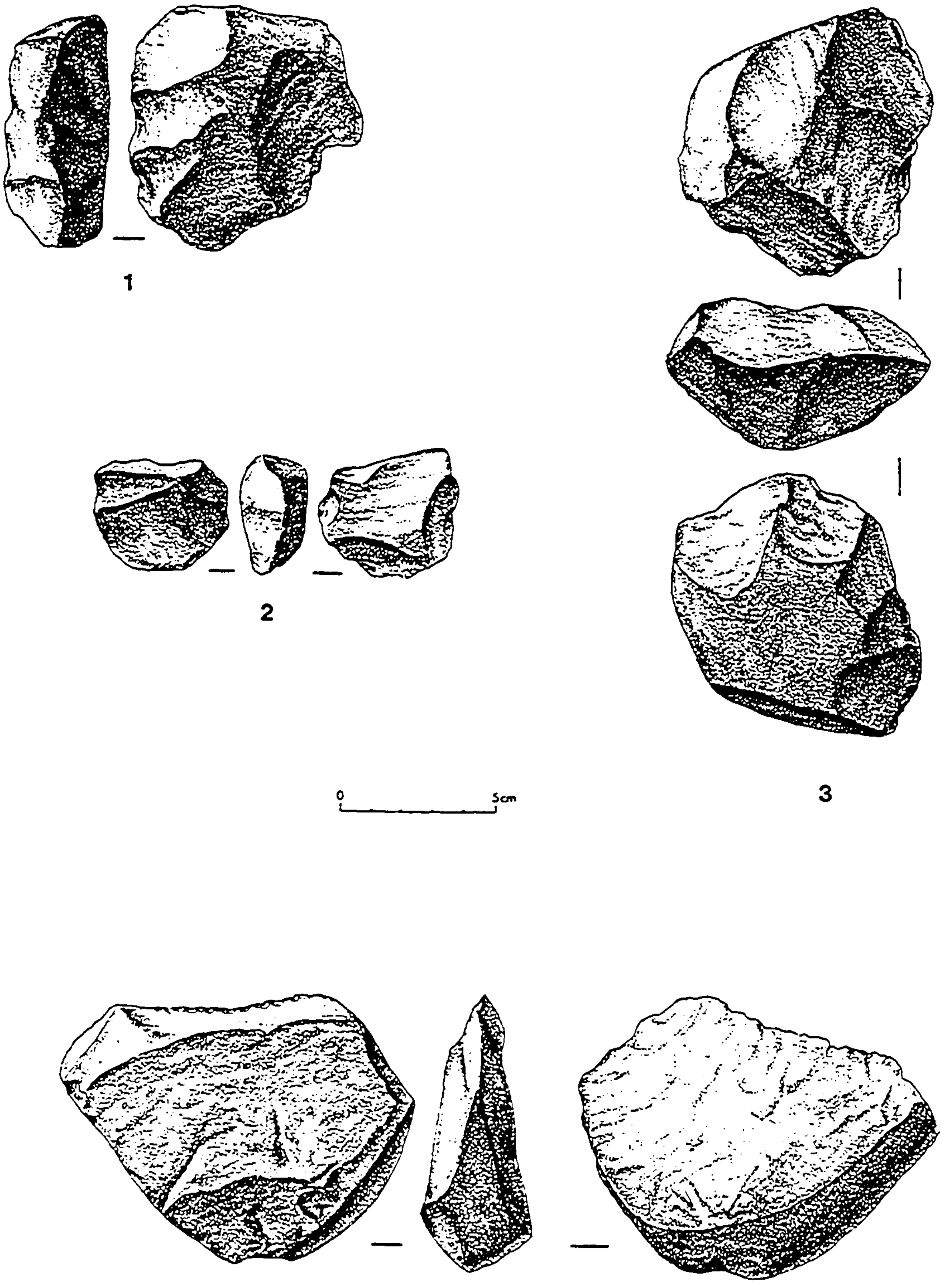


Fig. II 32. Tools of type F13 (1. P6271), F14 (2. P6280 3. P6270) and F18 (4. Liangshan 85.7) from Liangshan.

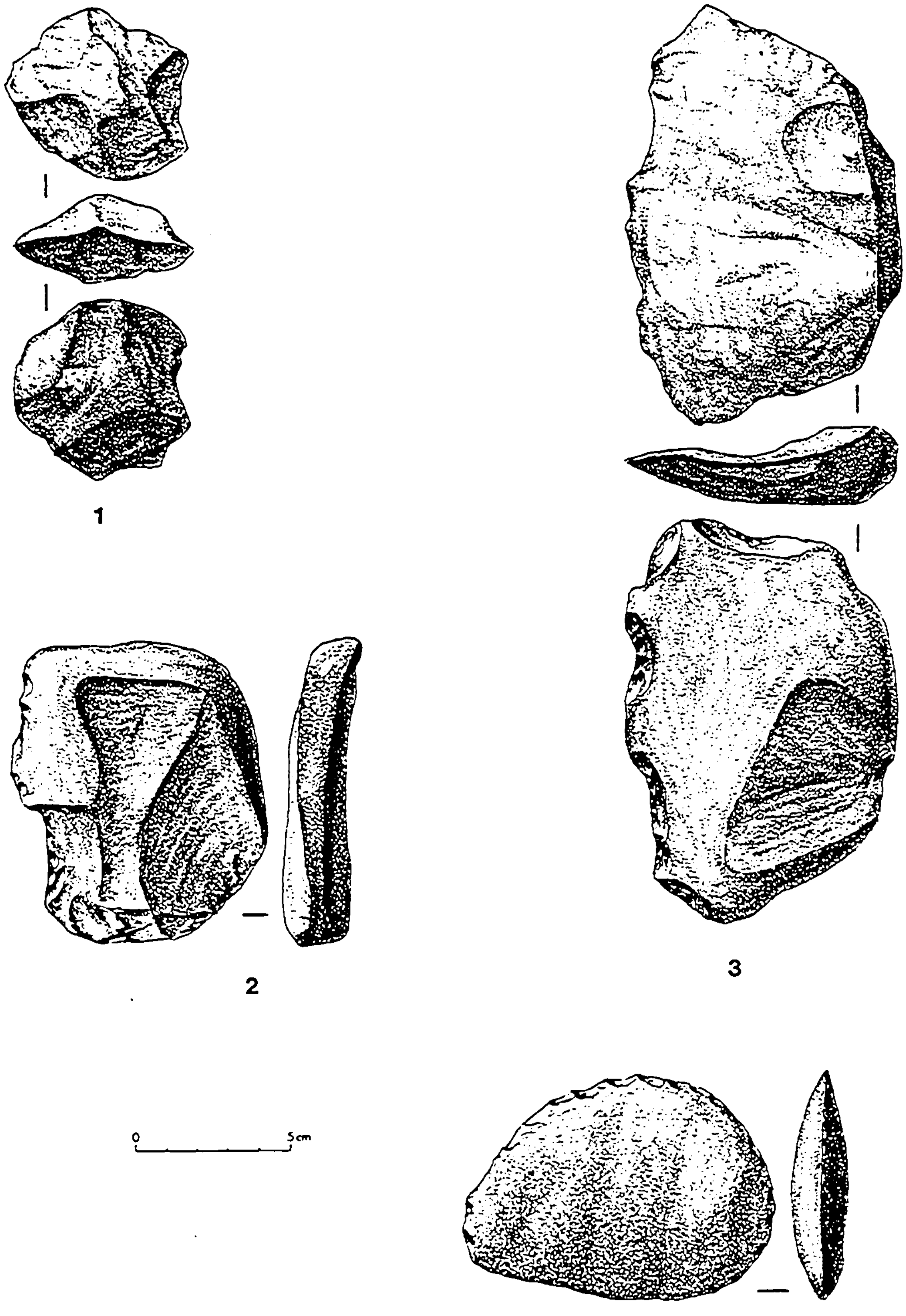


Fig. II 33. Tools of type F21 (1. P6279) and U1 (2. P6248 3. P6245 4. P6247) from Liangshan.

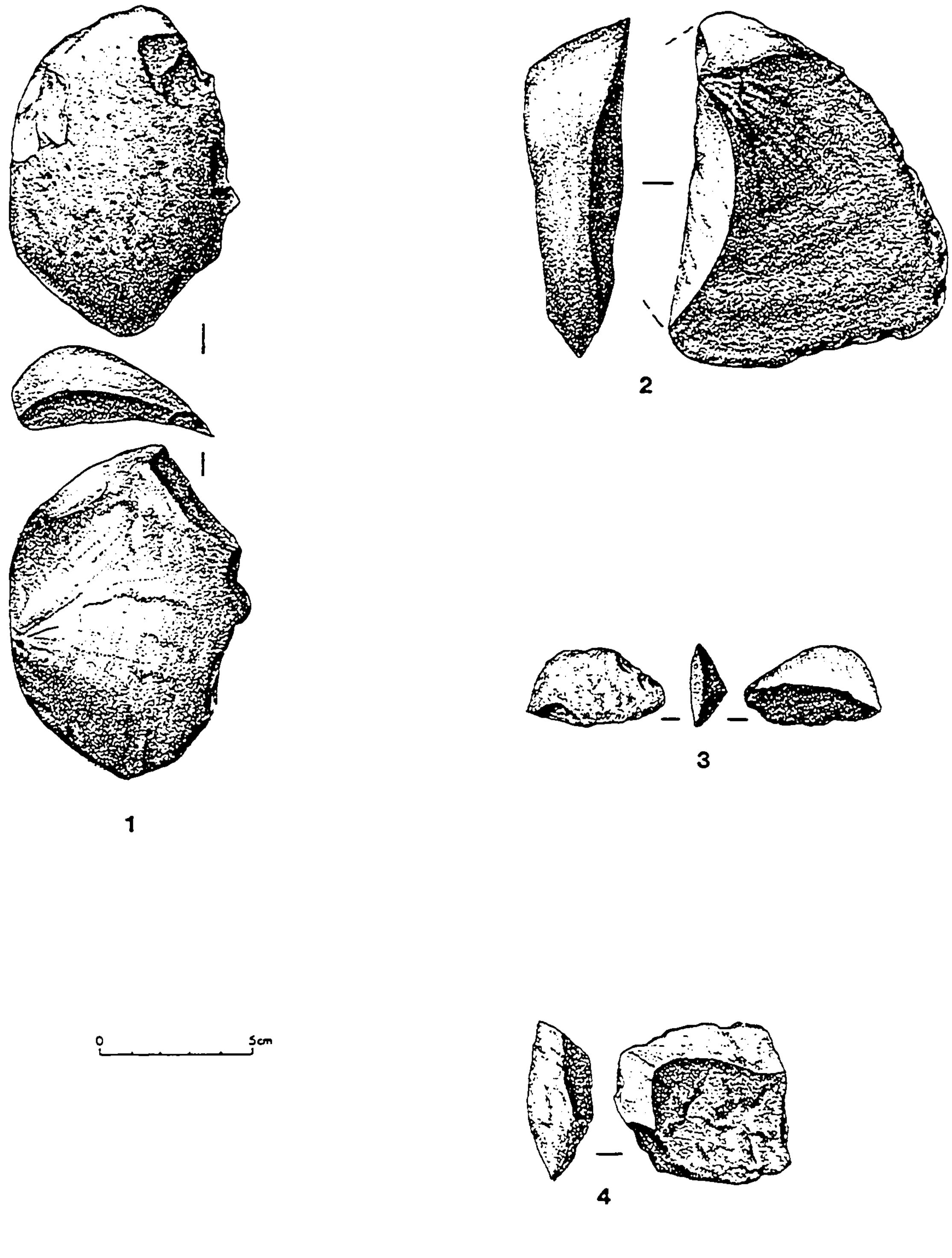


Fig. II 34. Tools of type U1 (1. Liangshan 85.5 2. Liangshan 85.3 3. Liangshan 85.9 4. P6282) from Liangshan.

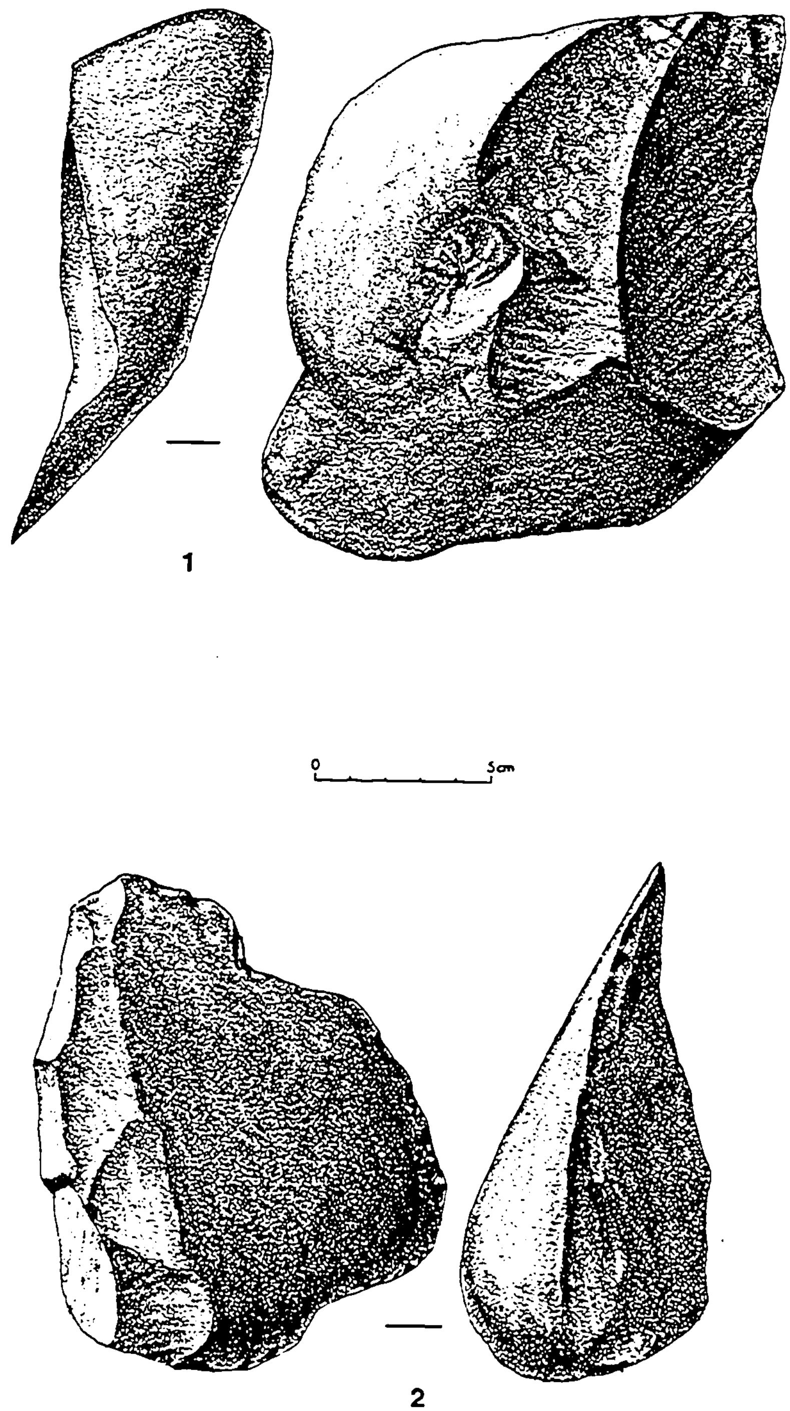


Fig. II 35. Tools of type U1 (1. P6229 2. P6228) from Liangshan.

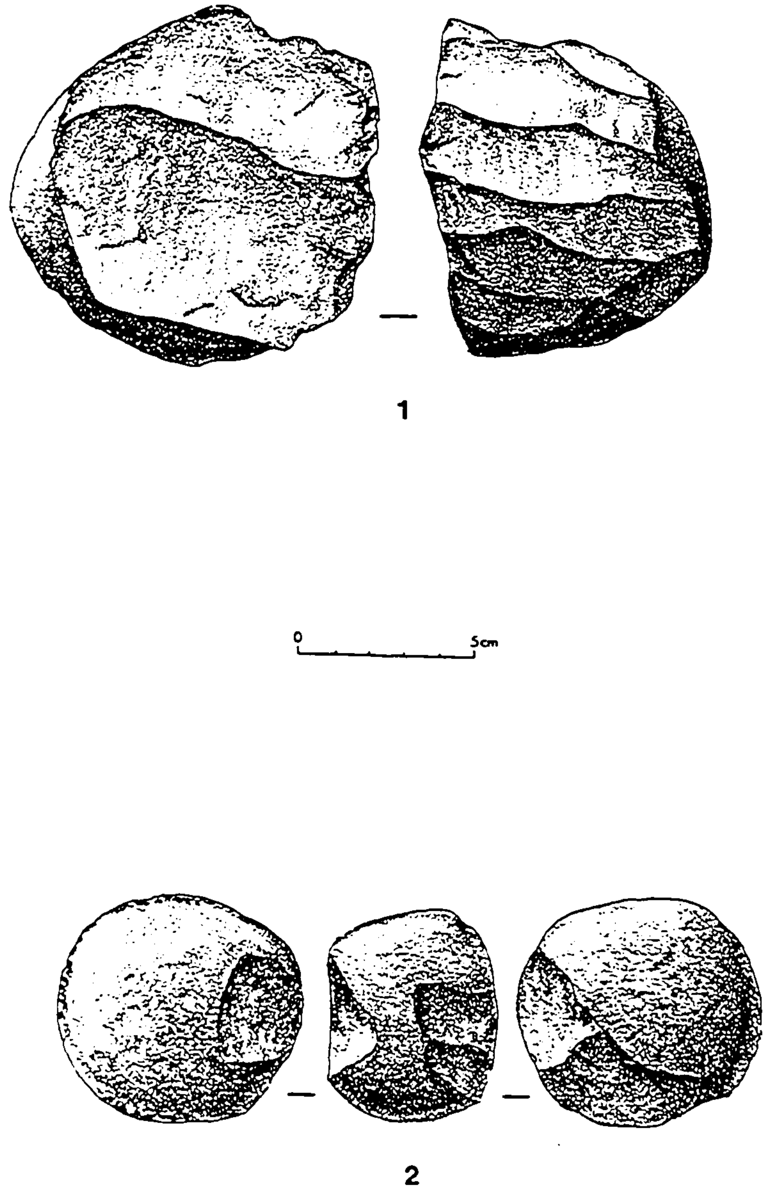


Fig. II 36. Tools of type D2 (1. Yangwangdong 008 2. P6309) from Liangshan.



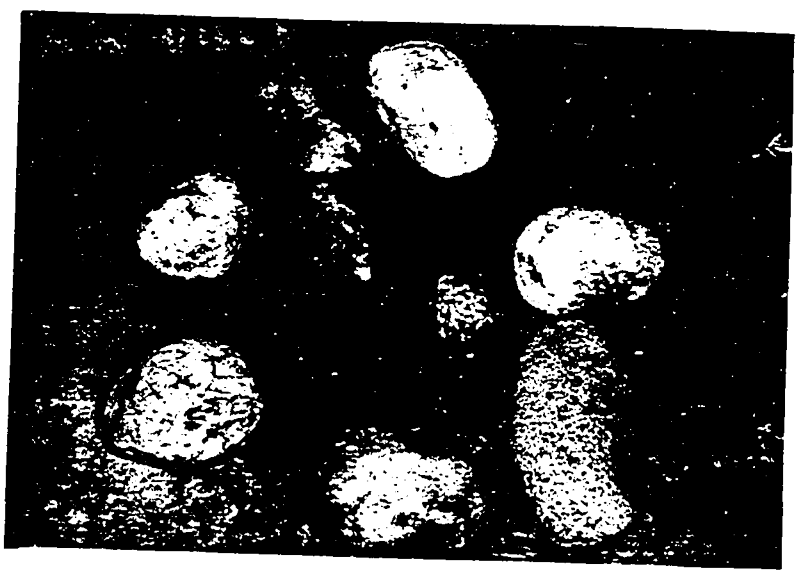


Fig. II 37. Cobbles used in the replicative studies, Liangshan (above), hammerstones used in the replicative studies, Liangshan (below).

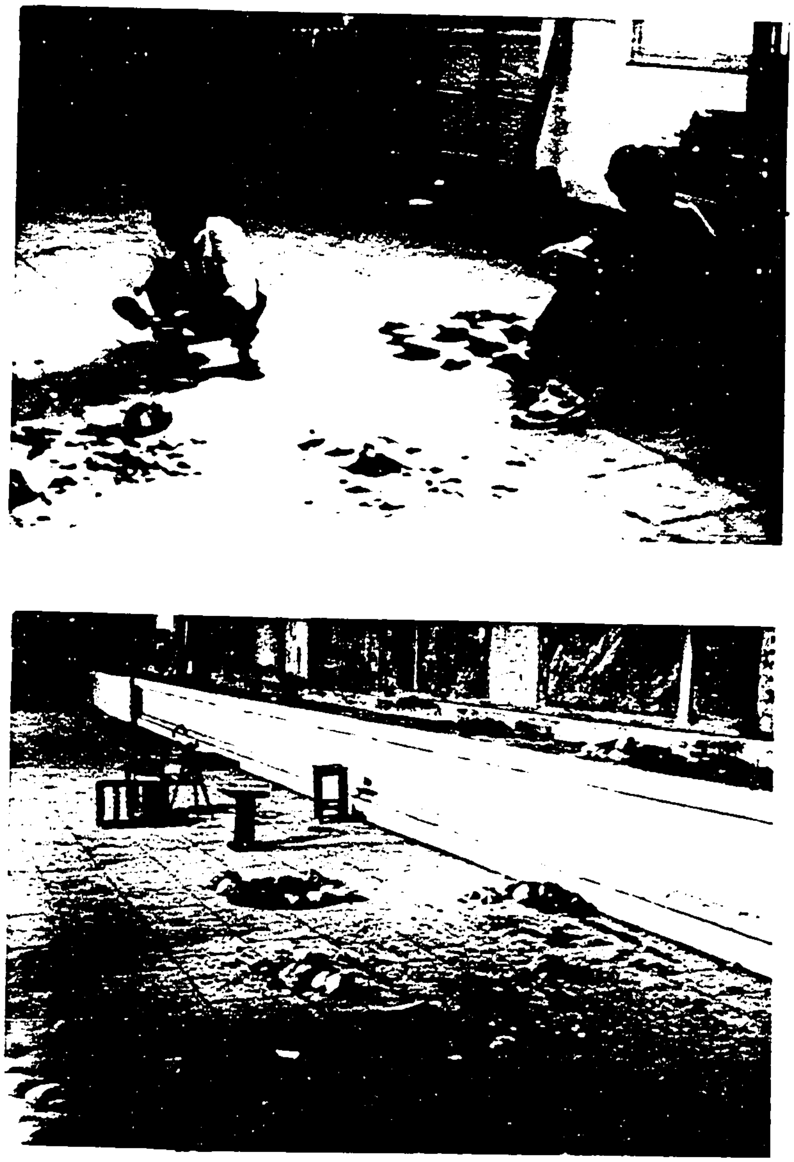


Fig. II 38. The replication area in the lab at Liangshan.



Fig. II 39. Replication at Liangshan. The primary trimming flake (left) is larger than the final core tool (right).

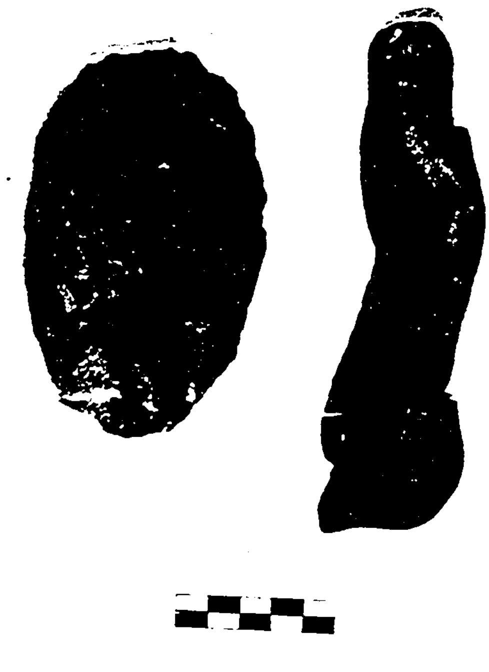


Fig. II 40. Replication at Liangshan. The primary trimming flake (right) is larger than the final core tool (right).

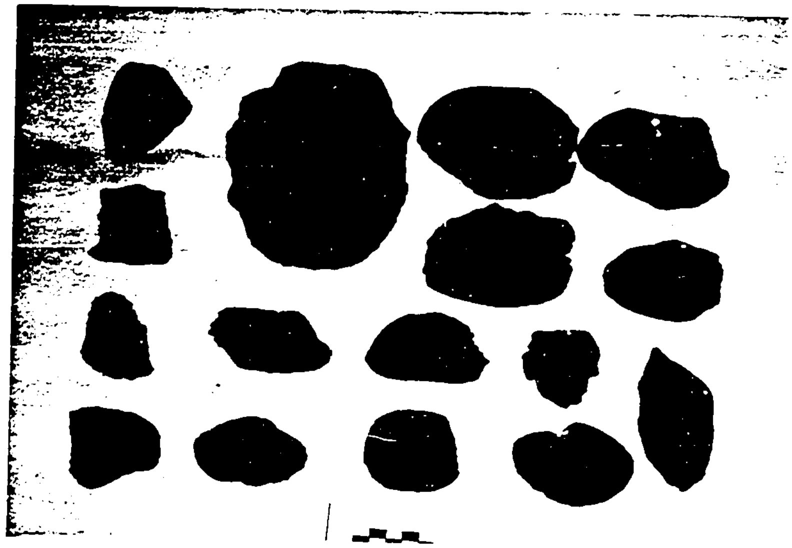




Fig. II 41. Replication: C15, of Liangshan (most flakes produced had breadths greater than their lengths).

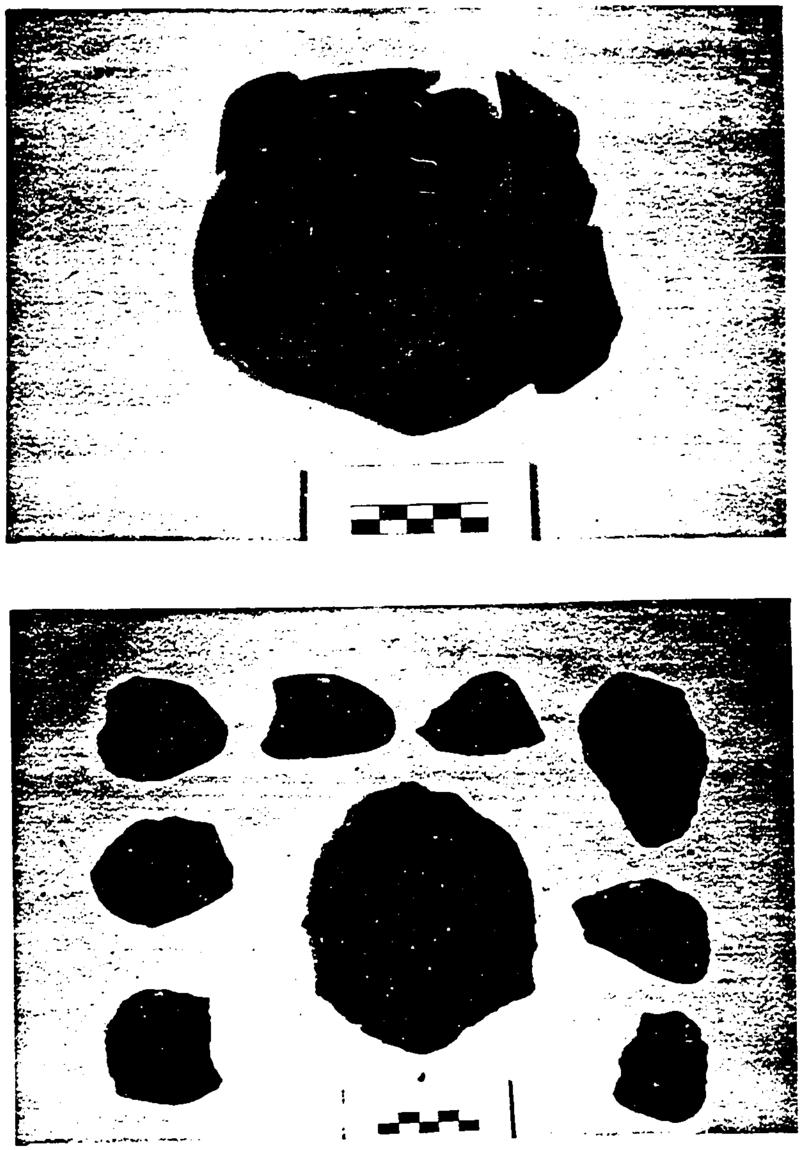


Fig. II 42. Replication: C15, of Liangshan (refitting: above).

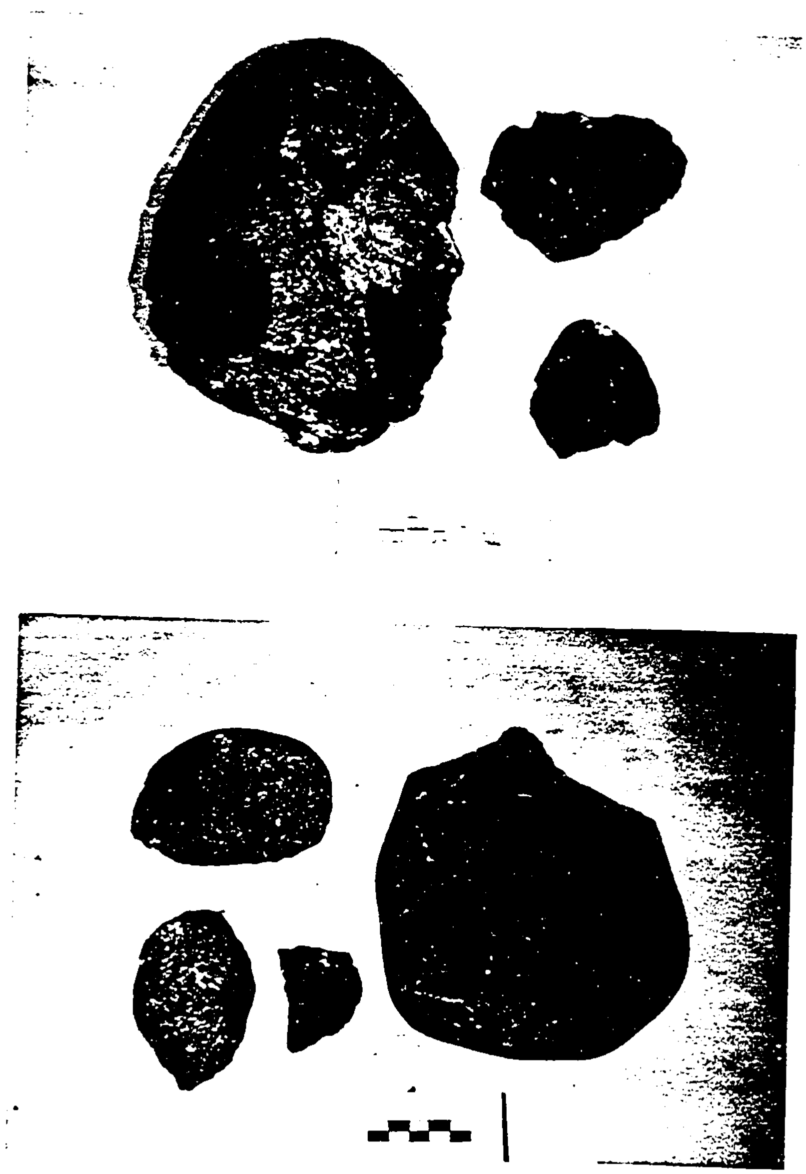


Fig. II 43. Two replications of type C1 tools, Liangshan.

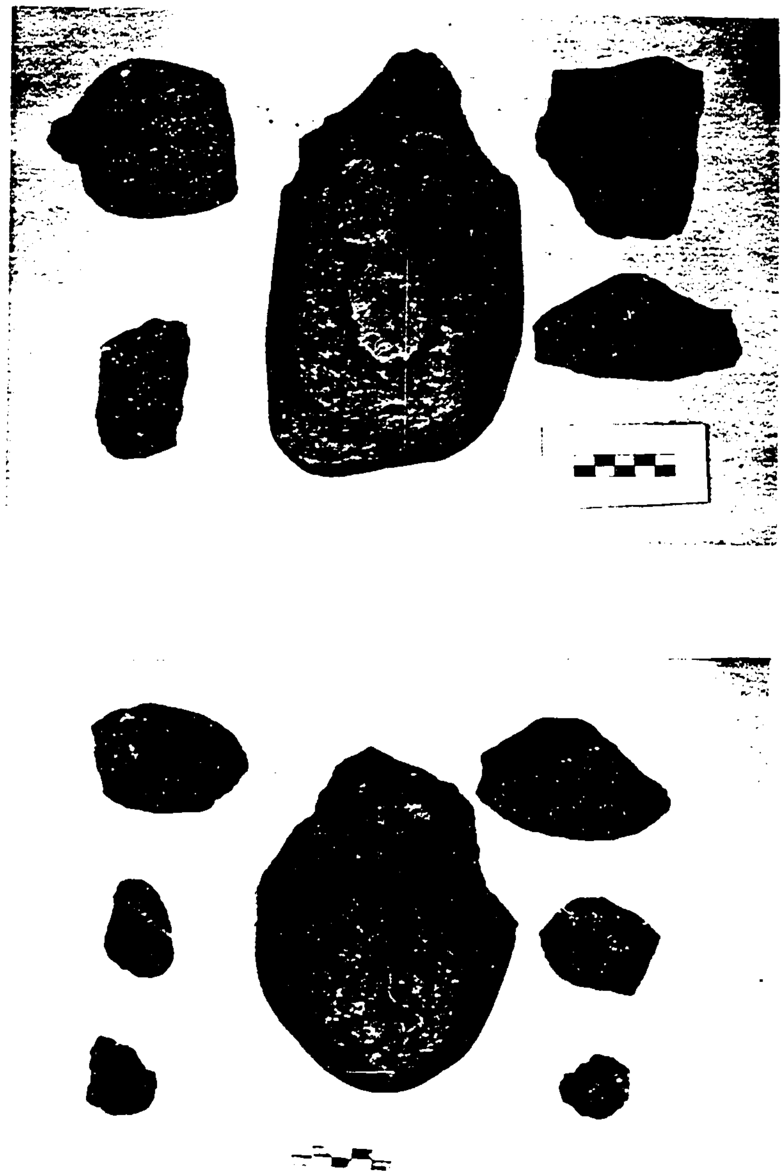


Fig. II 44. Replication: C9 and C10, of Liangshan.

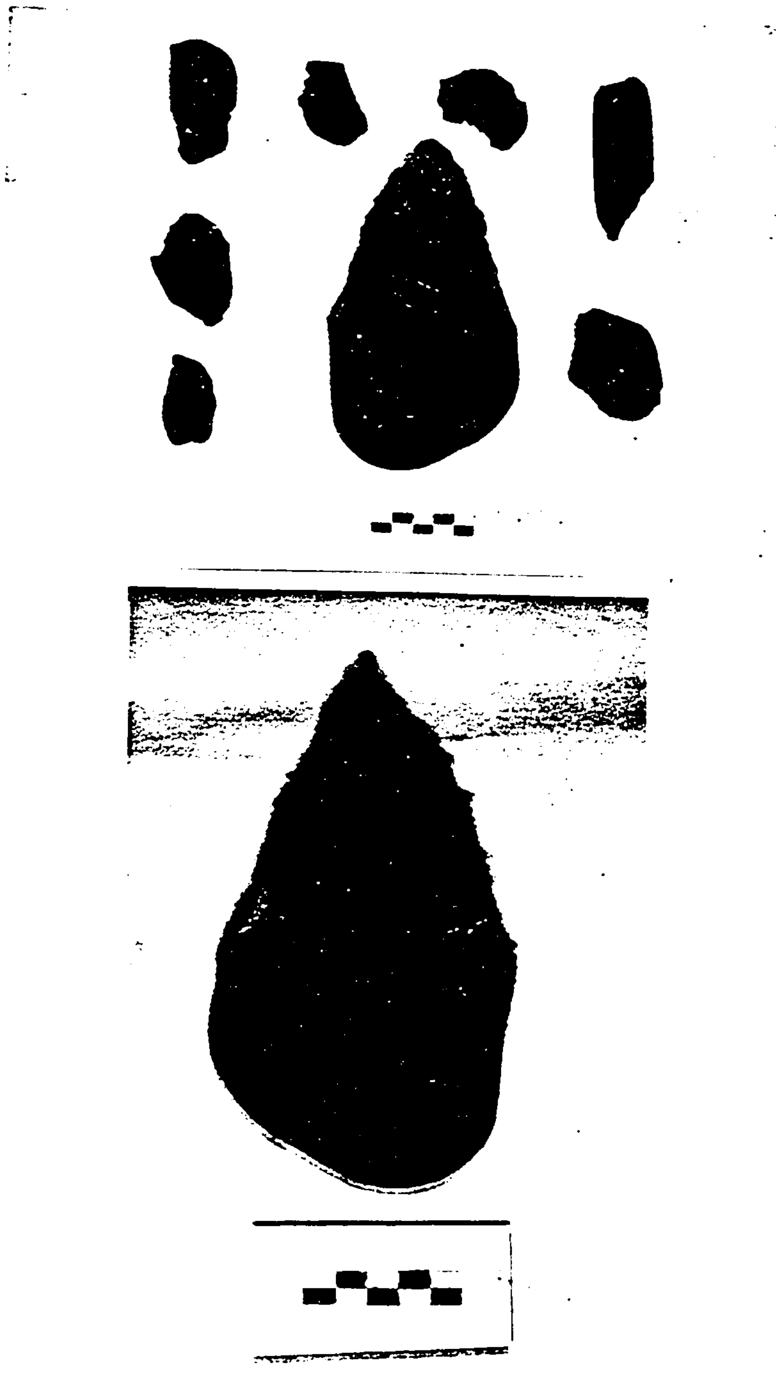


Fig. II 45. Replication: C13, of Liangshan.



Fig. II 46. Replication: C13, of Liangshan.

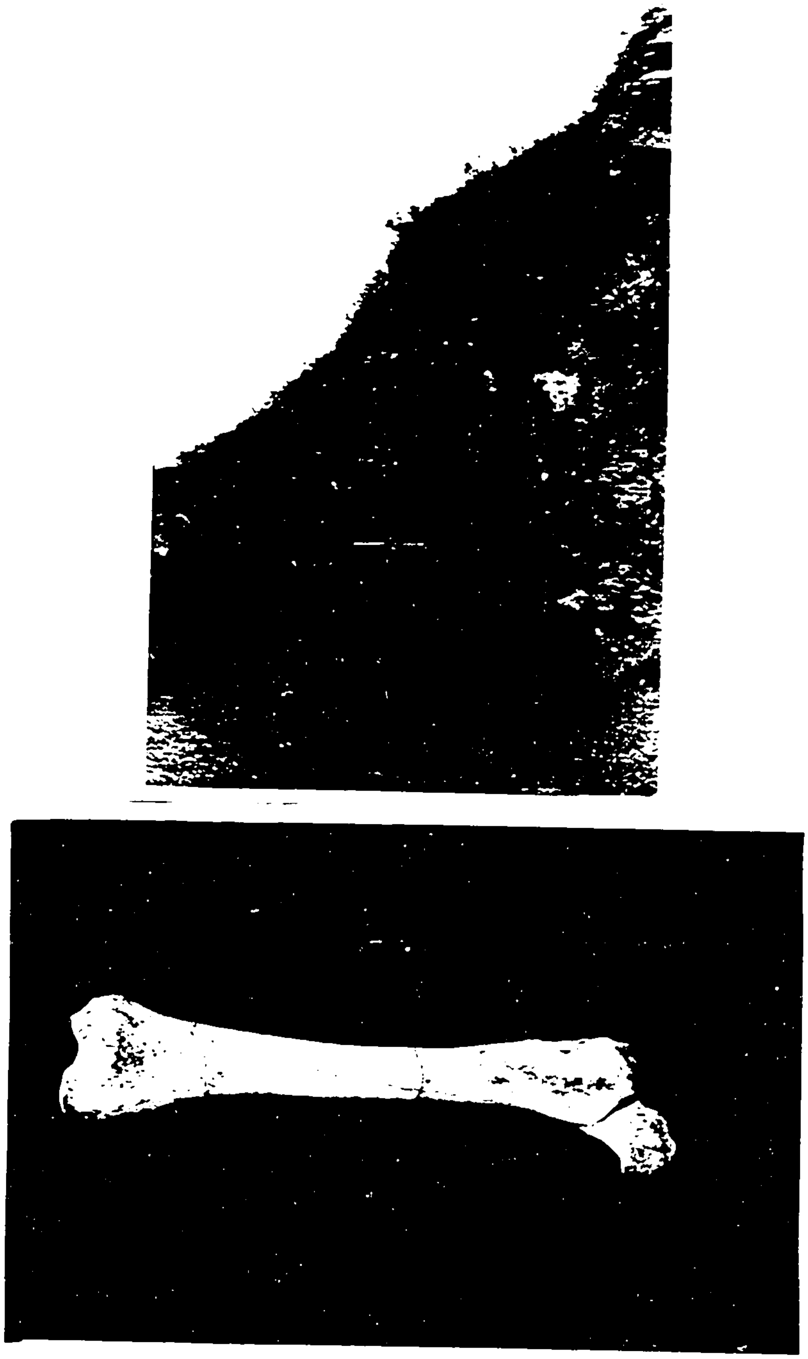


Fig. III 1. Remains of Shilongtou cave site (above), mammalian fossil collected from Shilongtou hill (below).

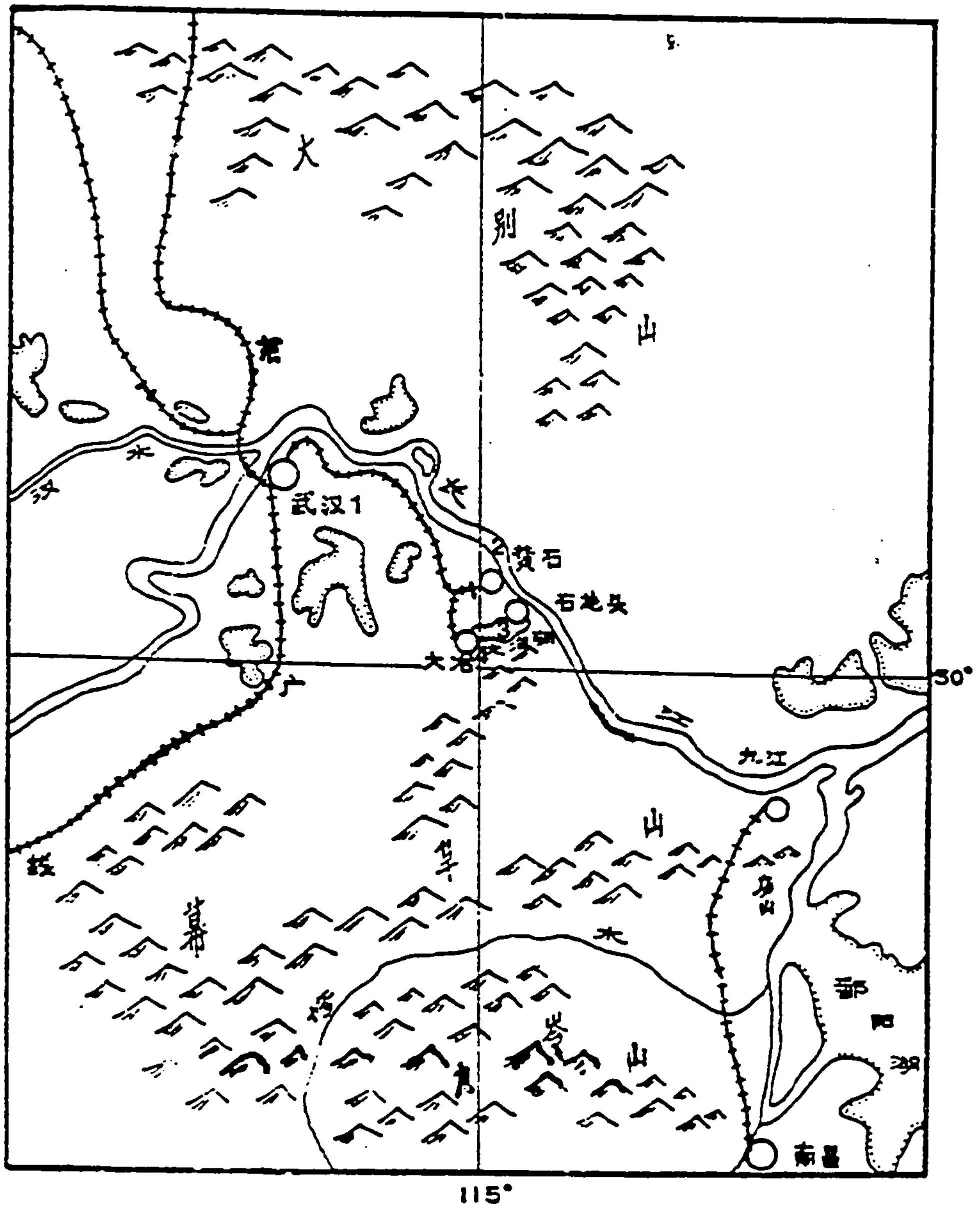


Fig. III 2. Map of Shilongtou cave site (Li, 1974: Fig. 1). Key: 1. Wuhan city 2. Yangtze River 3. Daye Lake 4. Shilongtou Cave

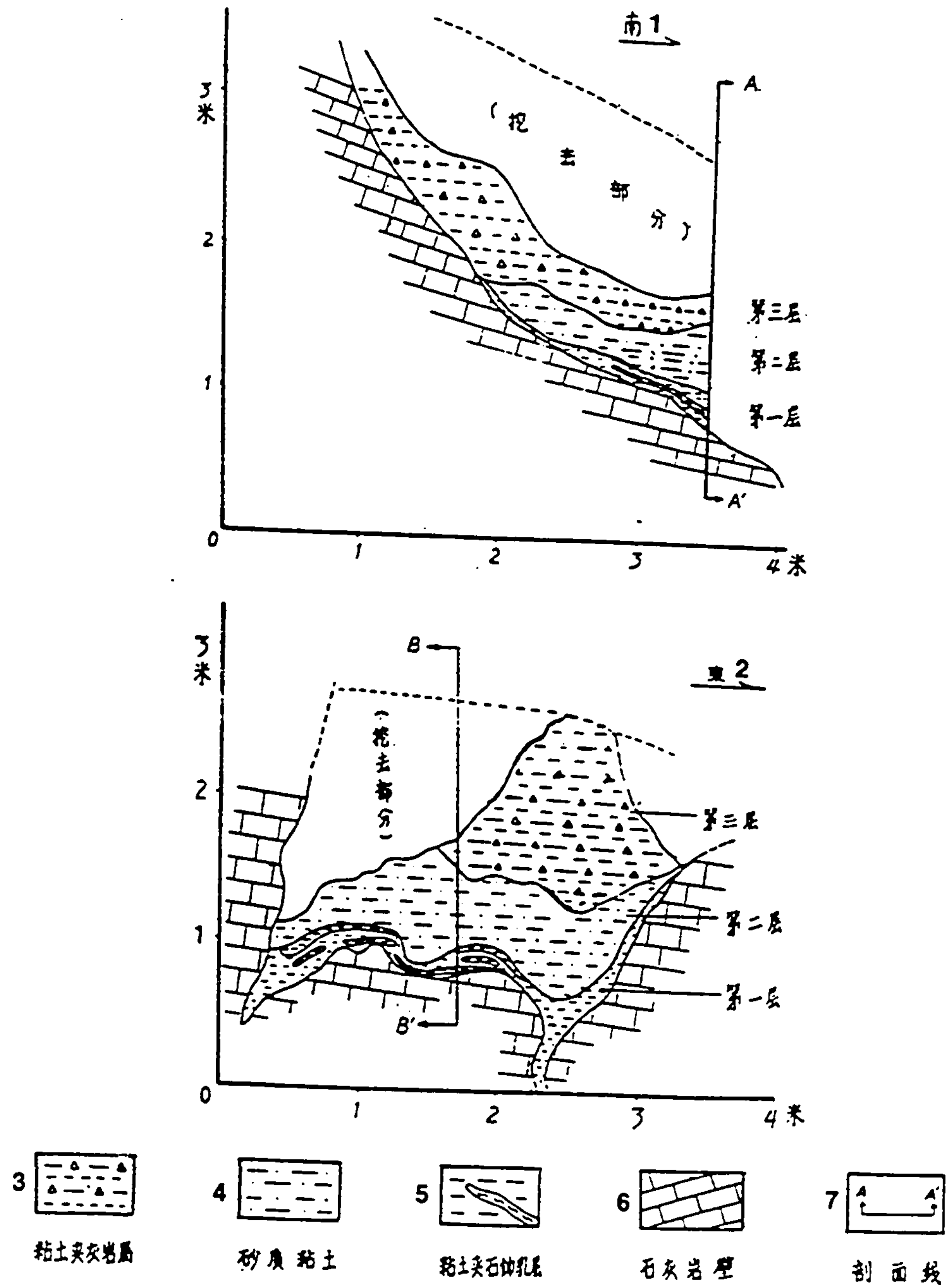


Fig. III 3. The stratigraphy of Shilongtou Cave (Li, 1974: Fig. 2). Key: 1. South 2. East 3. Clay with limestone fragments 4. Sandy clay 5. Clay with stalagmites 6. Limestone 7. Section

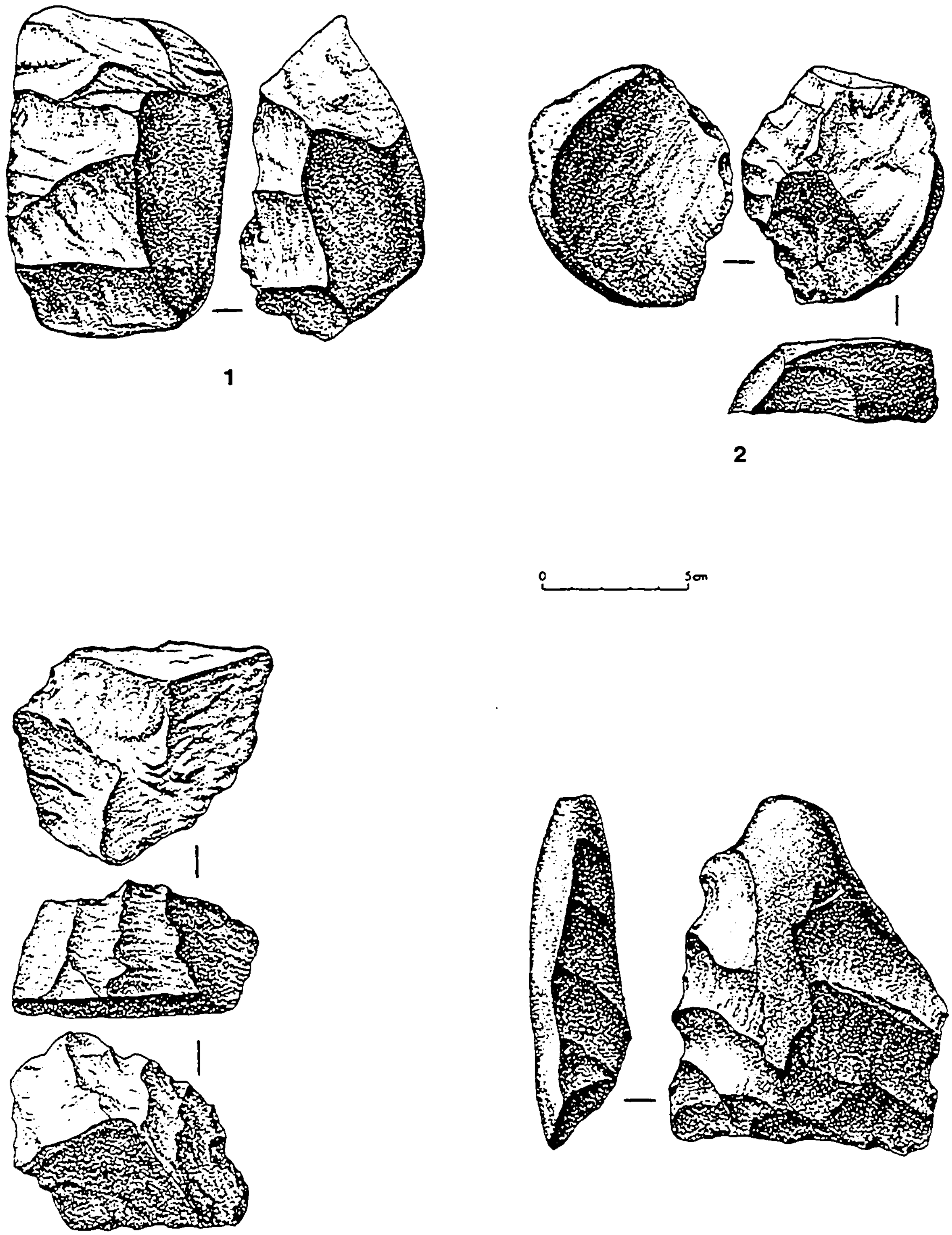


Fig. III 4. Tools of type C1 (1. P3822 2. P3842), C2 (3. P3831) and C3 (4. P3836) from Shilongtou.

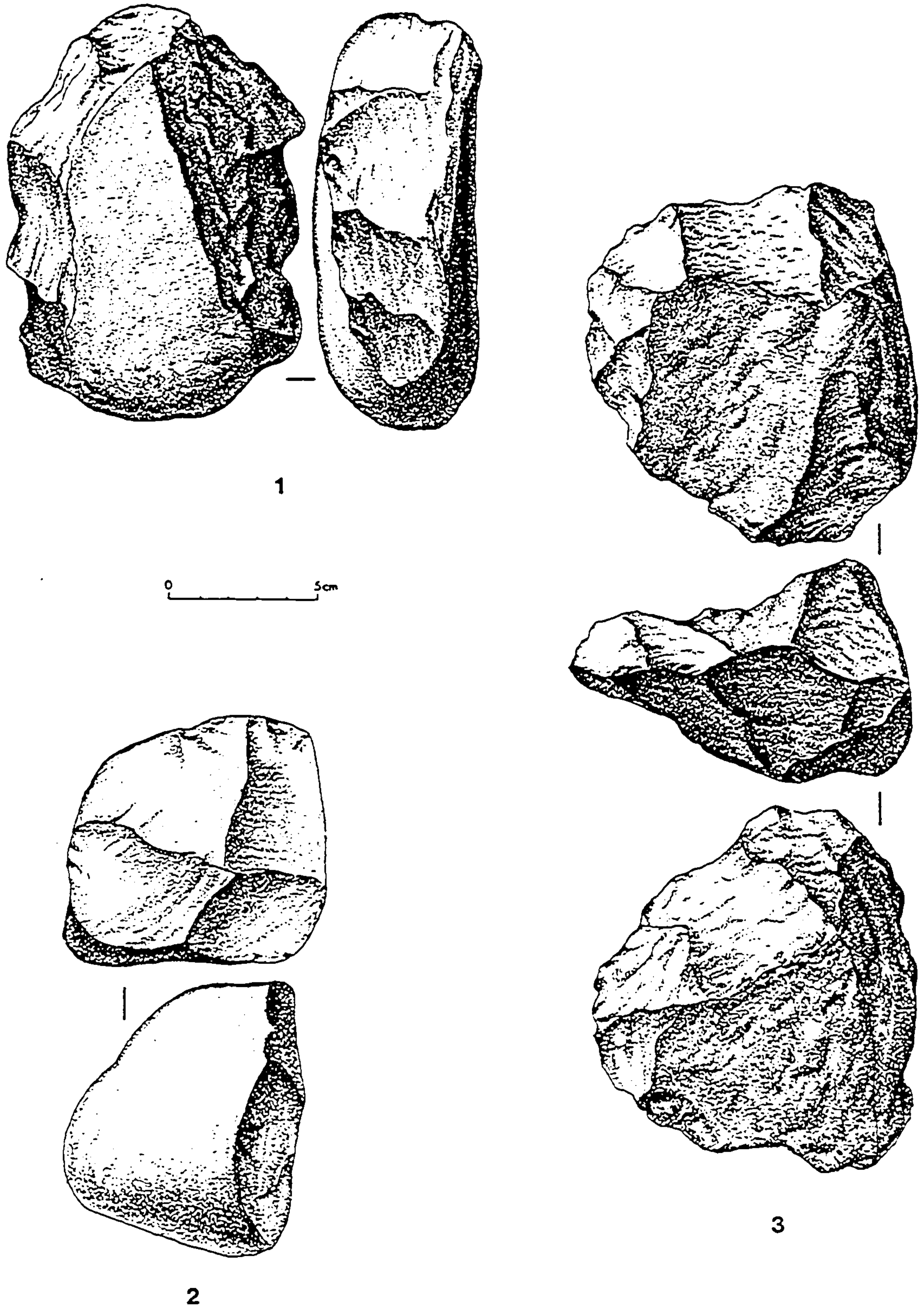


Fig. III 5. Tools of type C5 (1. P3837 3. P3838) and C8 (2. P3821) from Shilongtou.

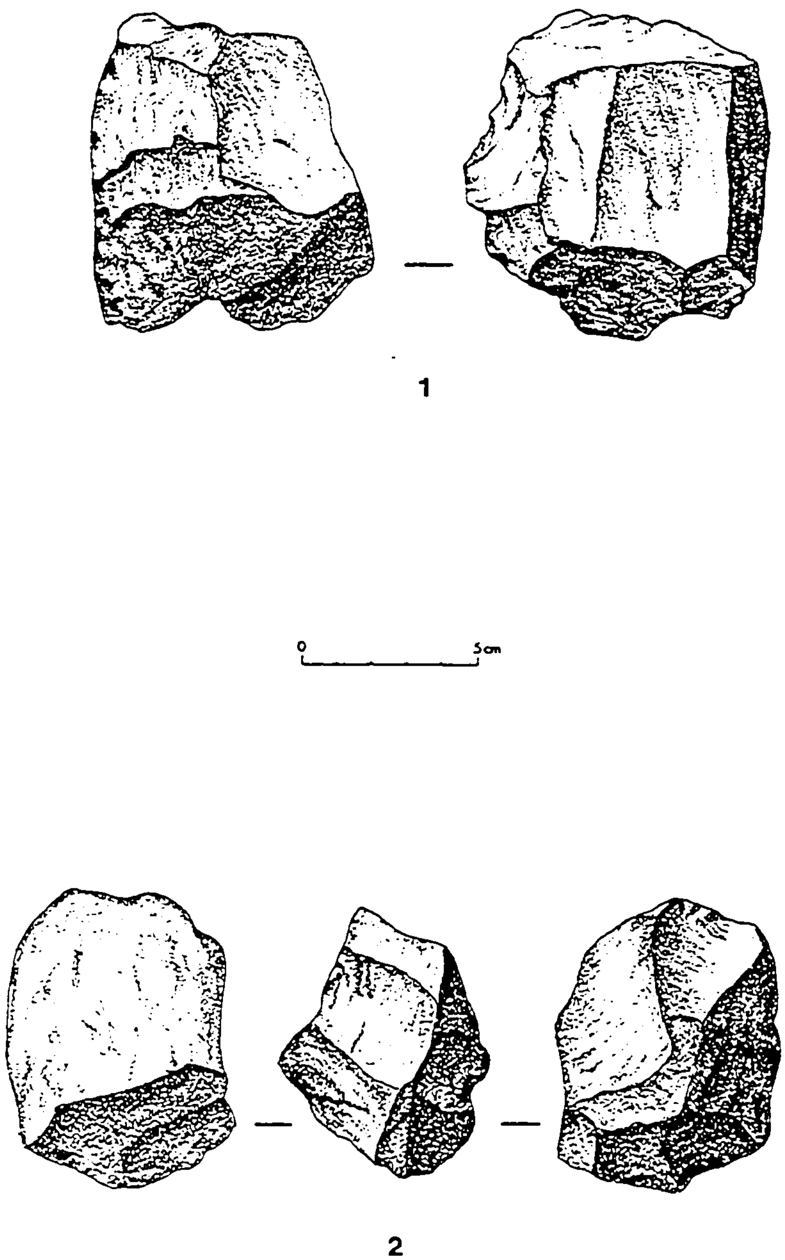


Fig. III 6. Tools of type C8 (1. P3823) and C7 (2. P3825) from Shilongtou.

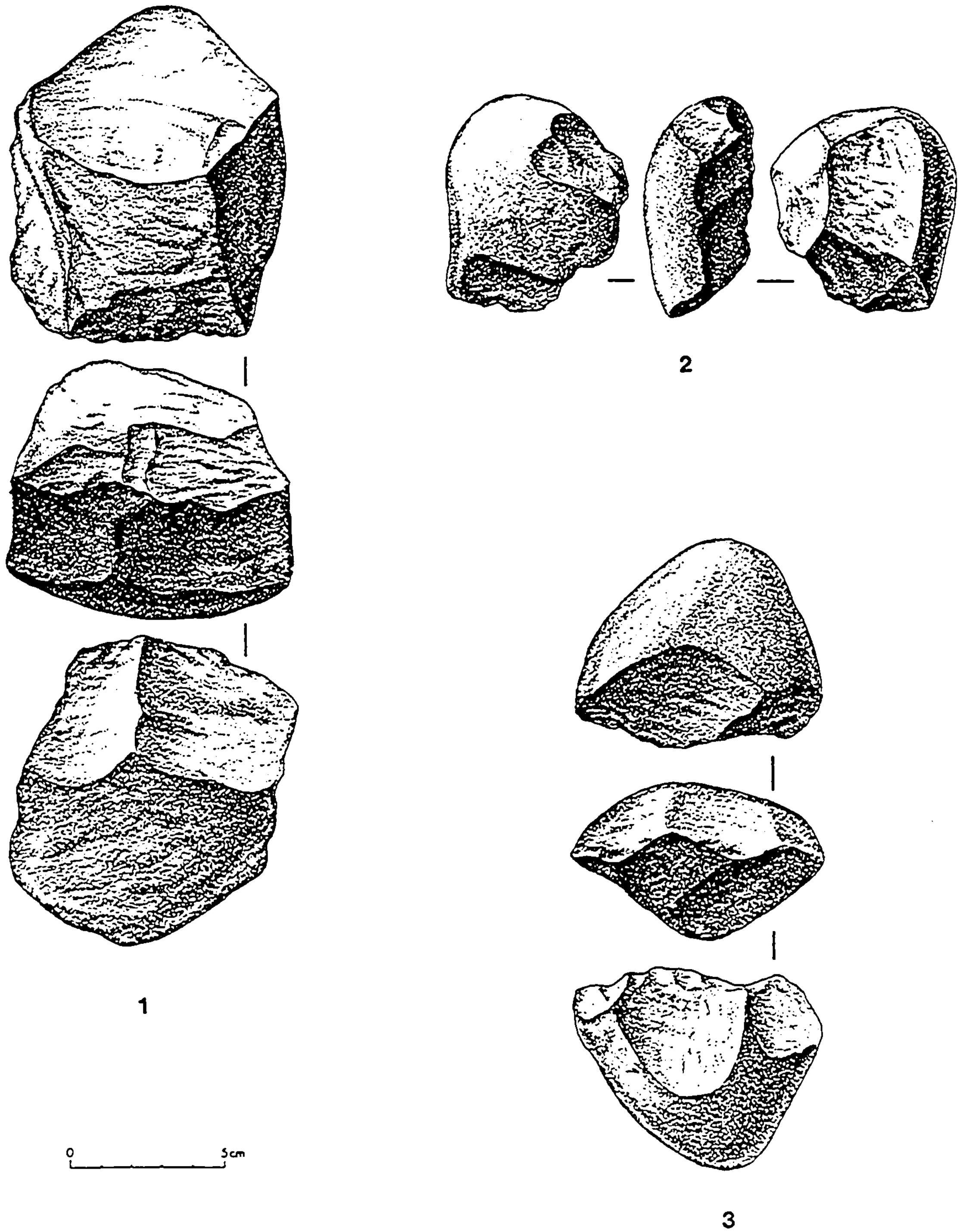


Fig. III 7. Tools of type C9 (1. P3824 2. P3841 3. P3835) from Shilongtou.

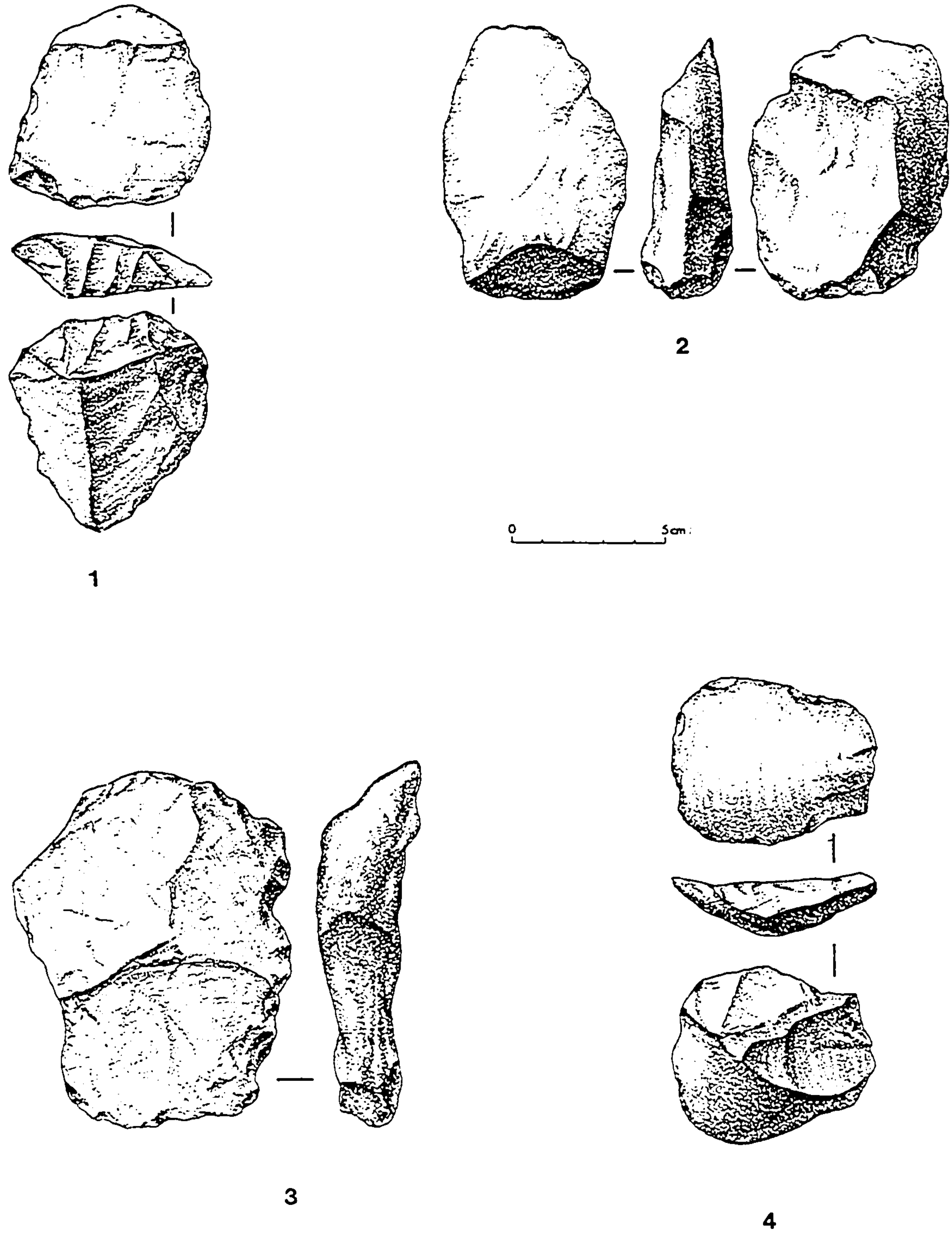


Fig. III 8. Tools of type F1 (1. P3845 2. P3830 3. P3834 4. P3826) from Shilongtou.

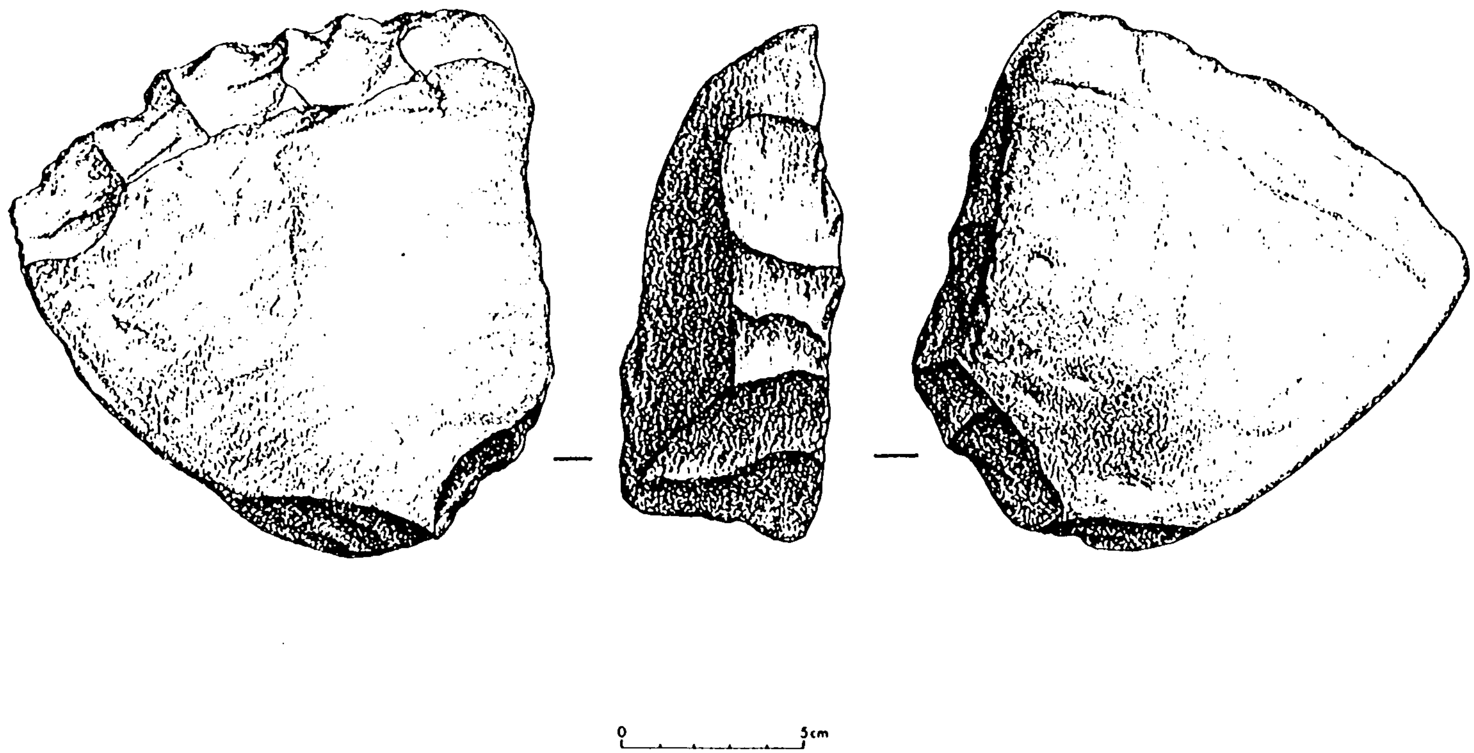


Fig. III 9. Tool of type F9 (P3832) from Shilongtou.

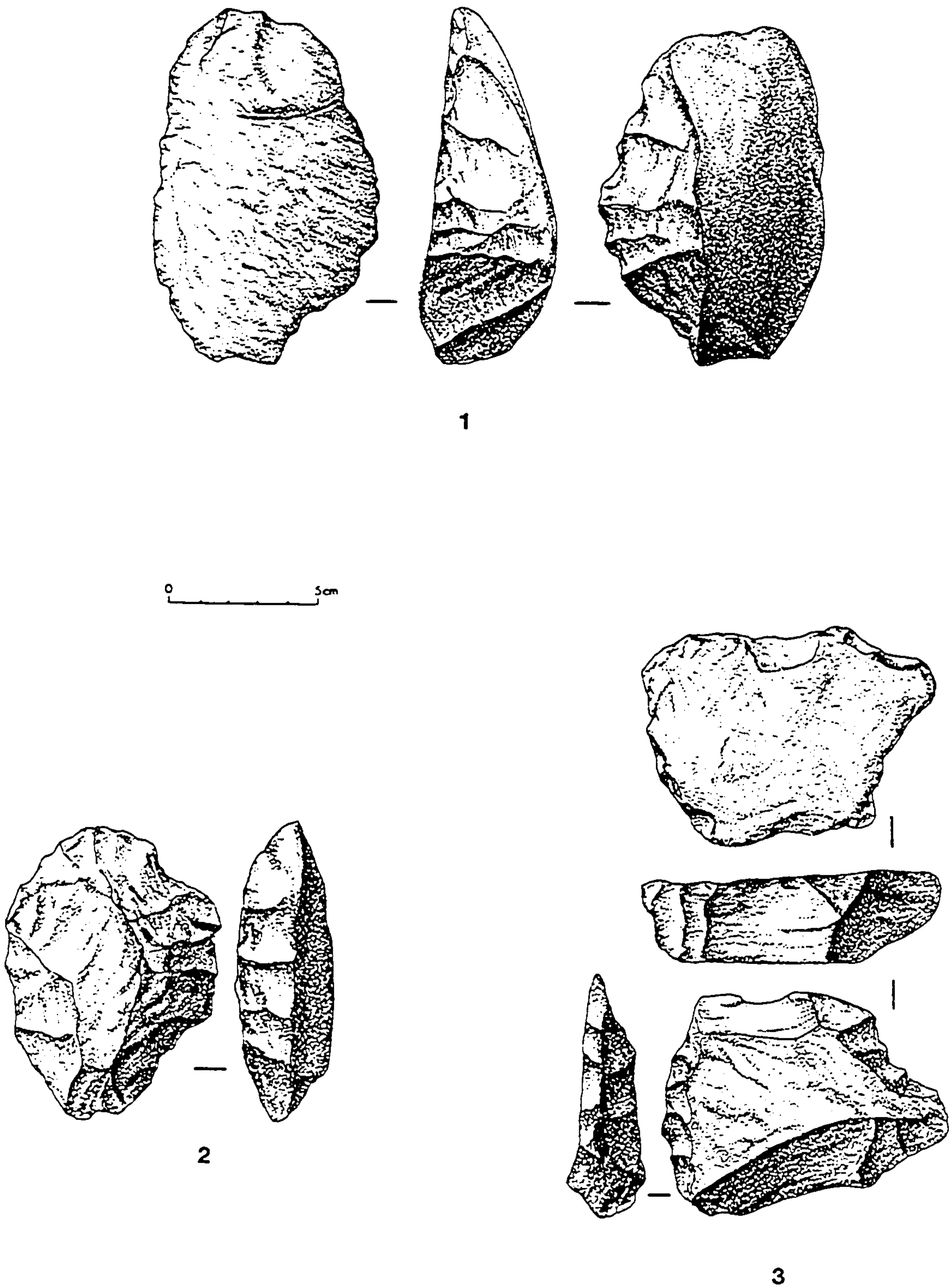


Fig. III 10. Tools of type F8 (1. P3833) and F10 (2. P3843 3. P3844) from Shilongtou.

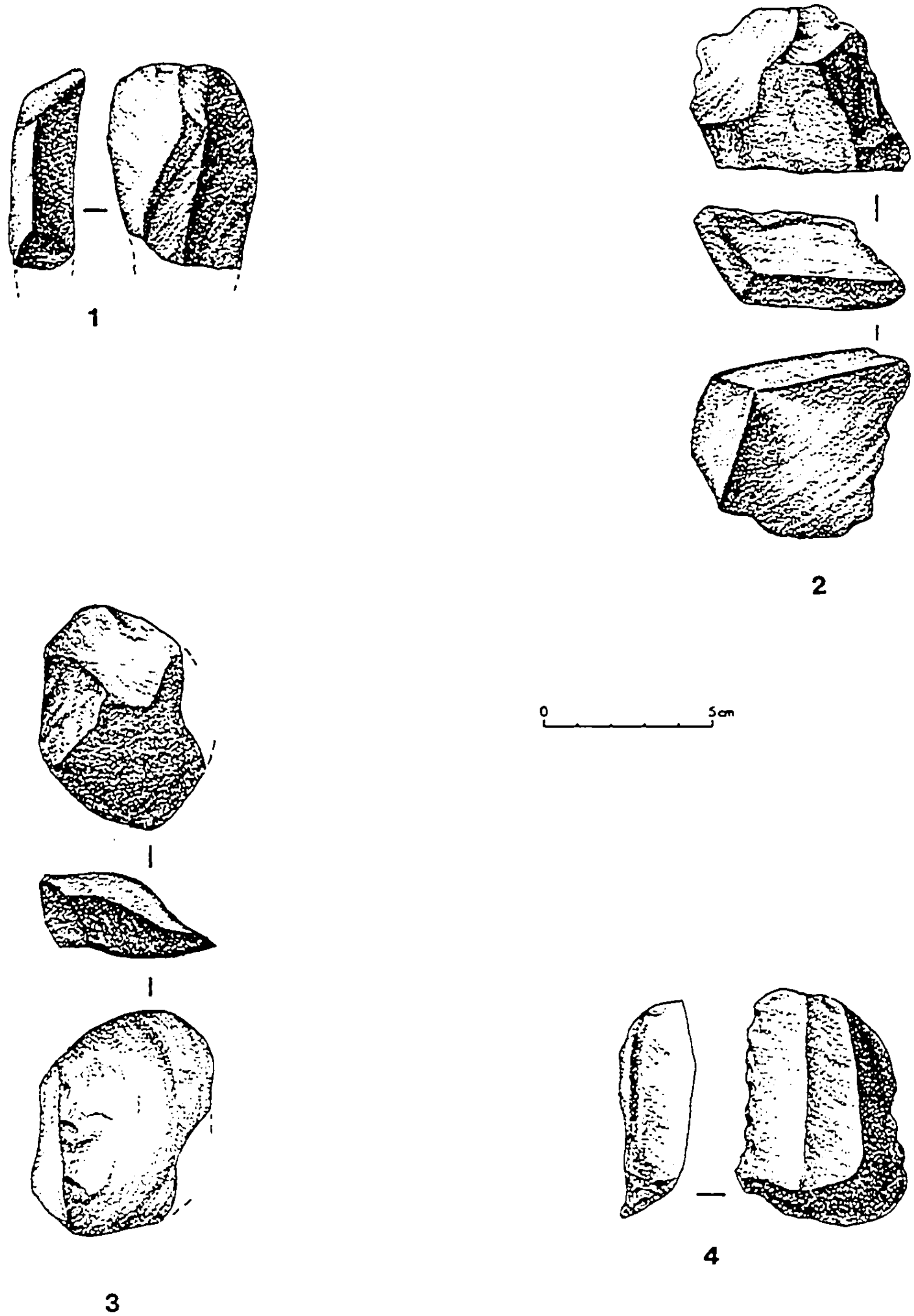


Fig. III 11. Tools of type U1 (1. P3829 3. P3828 4. P3840) and F11 (2. P3827) from Shilongtou.





Fig. III 12. Cobbles (av. cobble size 135x104x65 mm.) used in the replicative studies, Shilongtou.

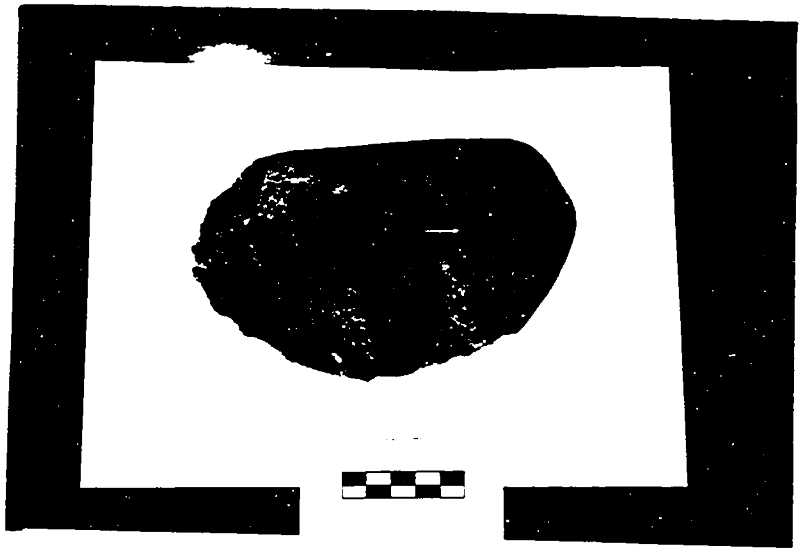




Fig. III 13. Hammerstone used in the replicative studies of Shilongtou site (above), replication: C8, of Shilongtou site (below).

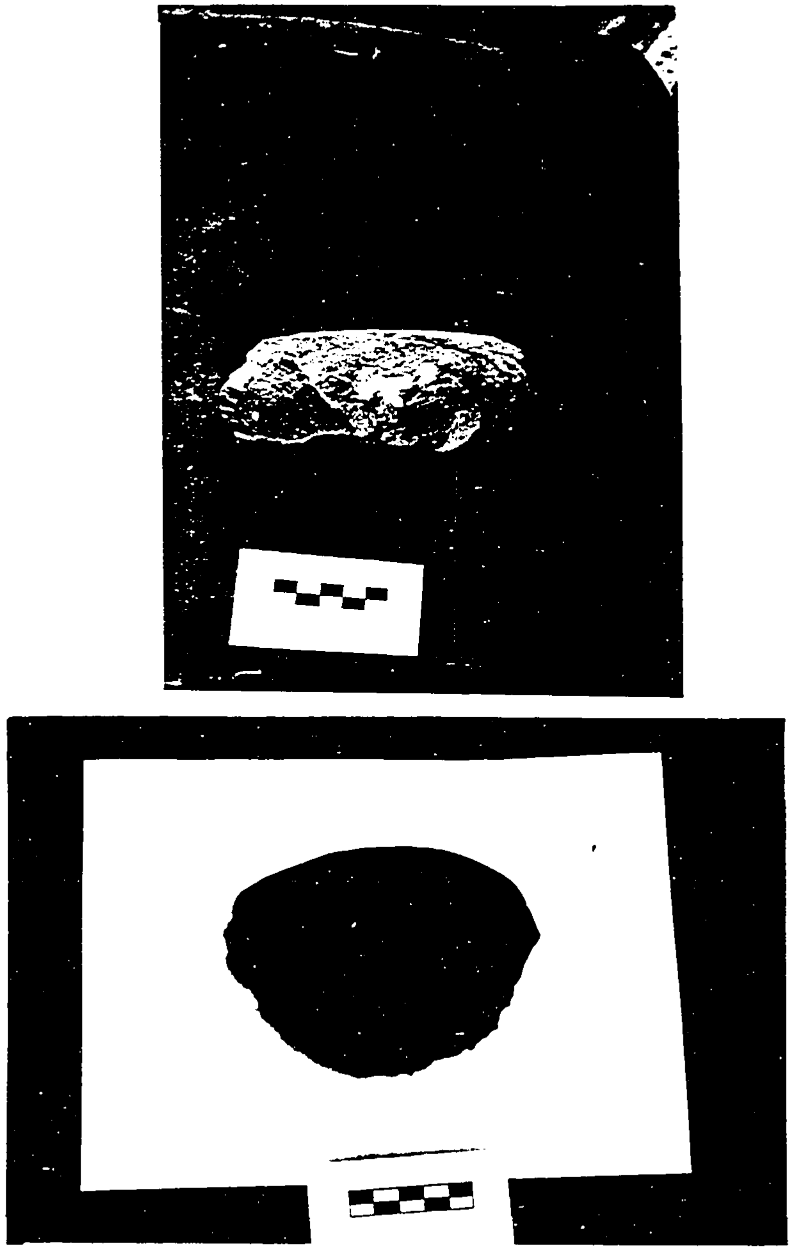


Fig. III 14. Replication: bifacial trimming edge (above), unifacial trimming edge (below).

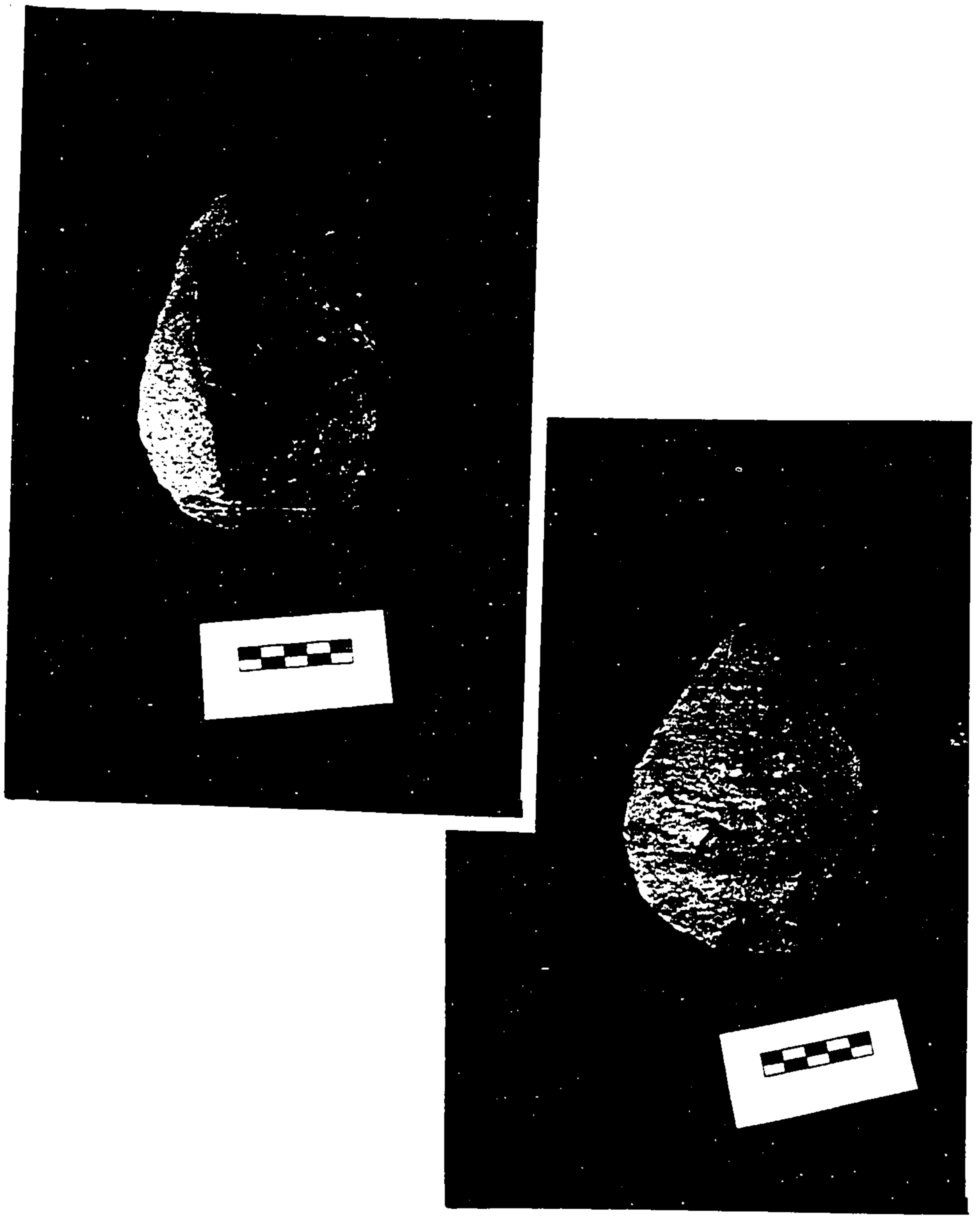


Fig. III 15. Replication: C13, of Shilongtou.

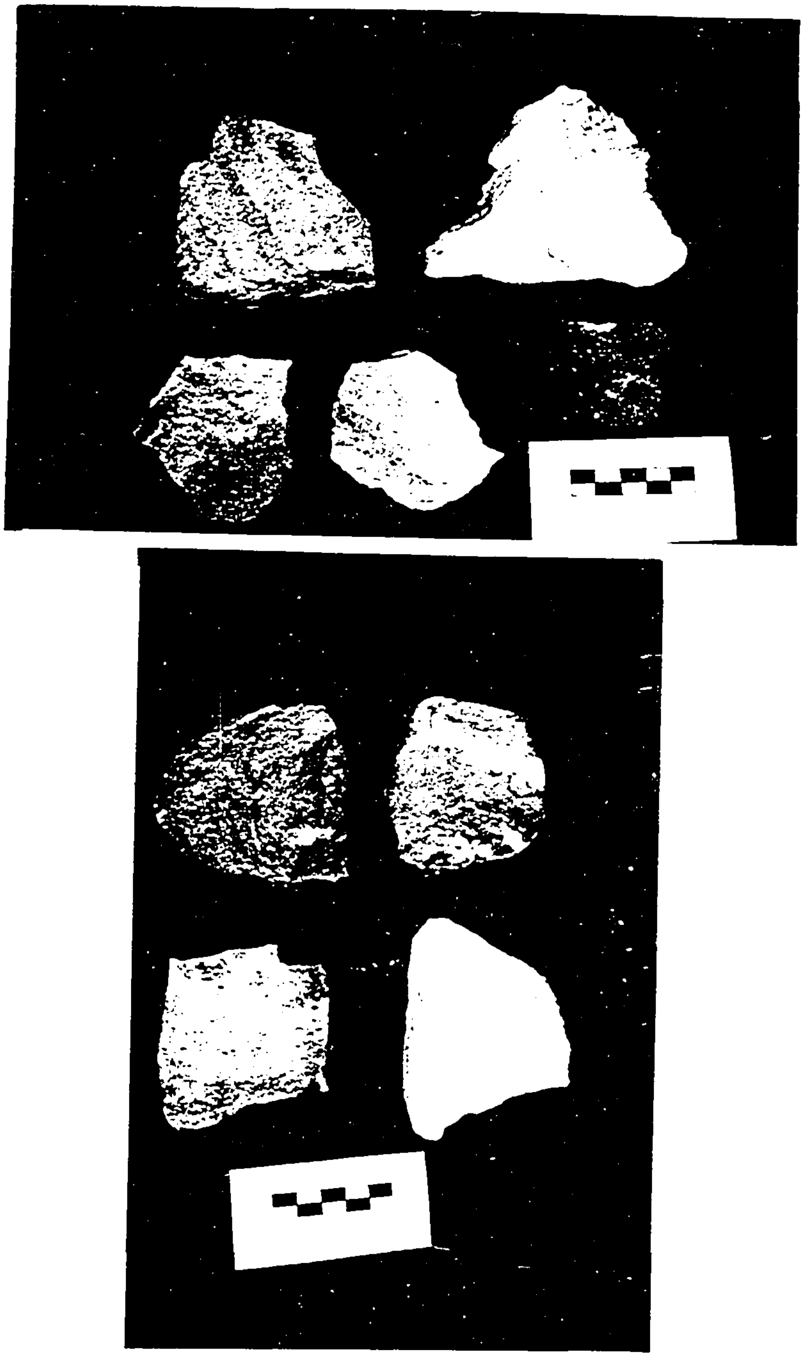
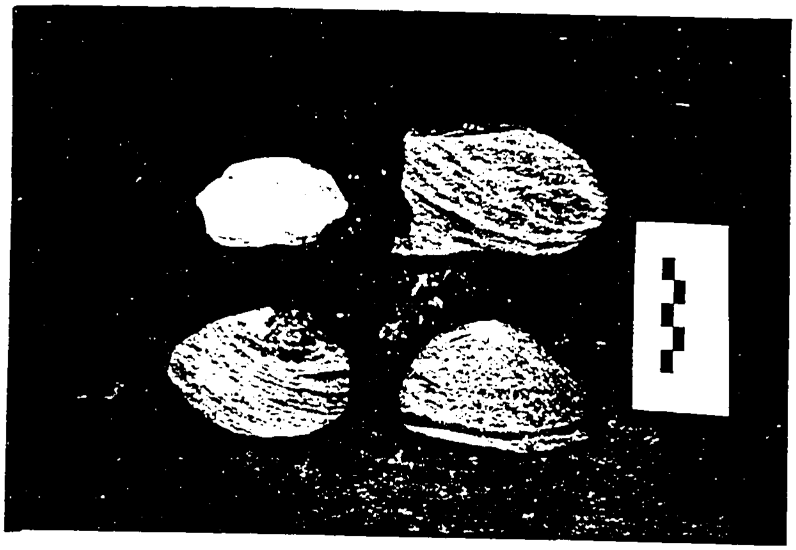


Fig. III 16. Replication: flakes from Shilongtou.



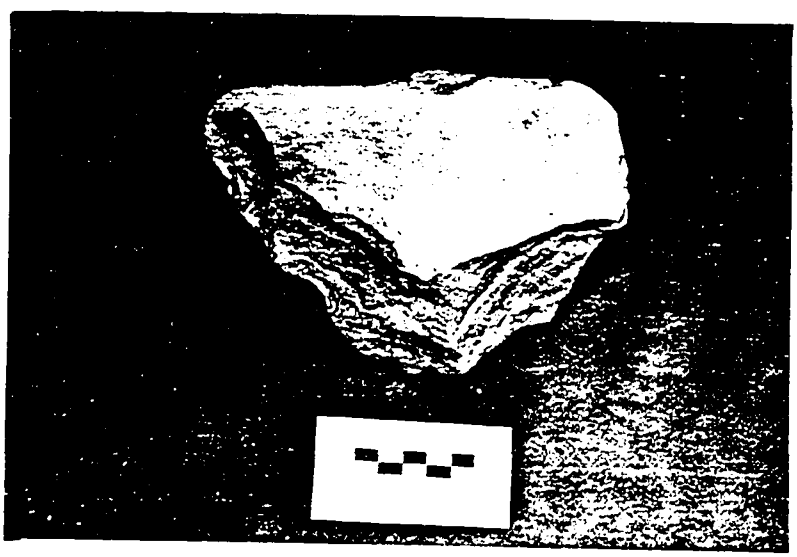


Fig. III 17. Replication: Cl, of Shilongtou.

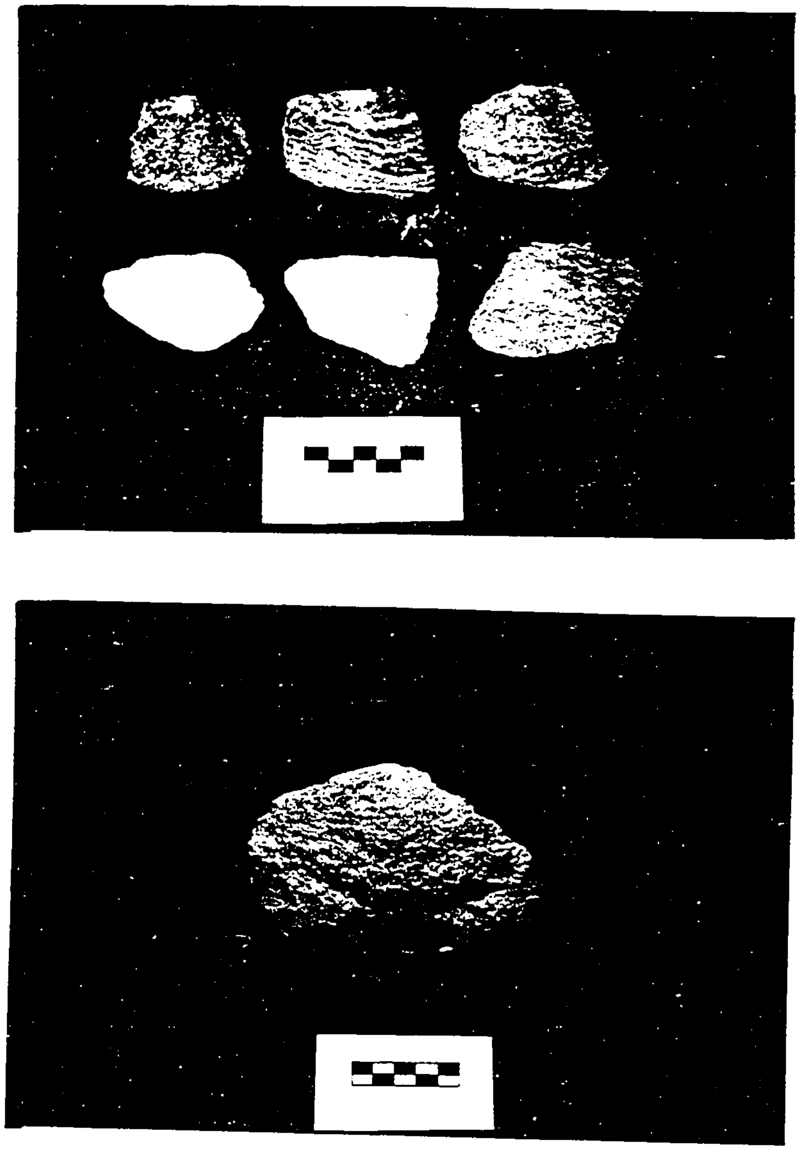


Fig. III 18. Replication: flakes with greater width than length, Shilongtou.

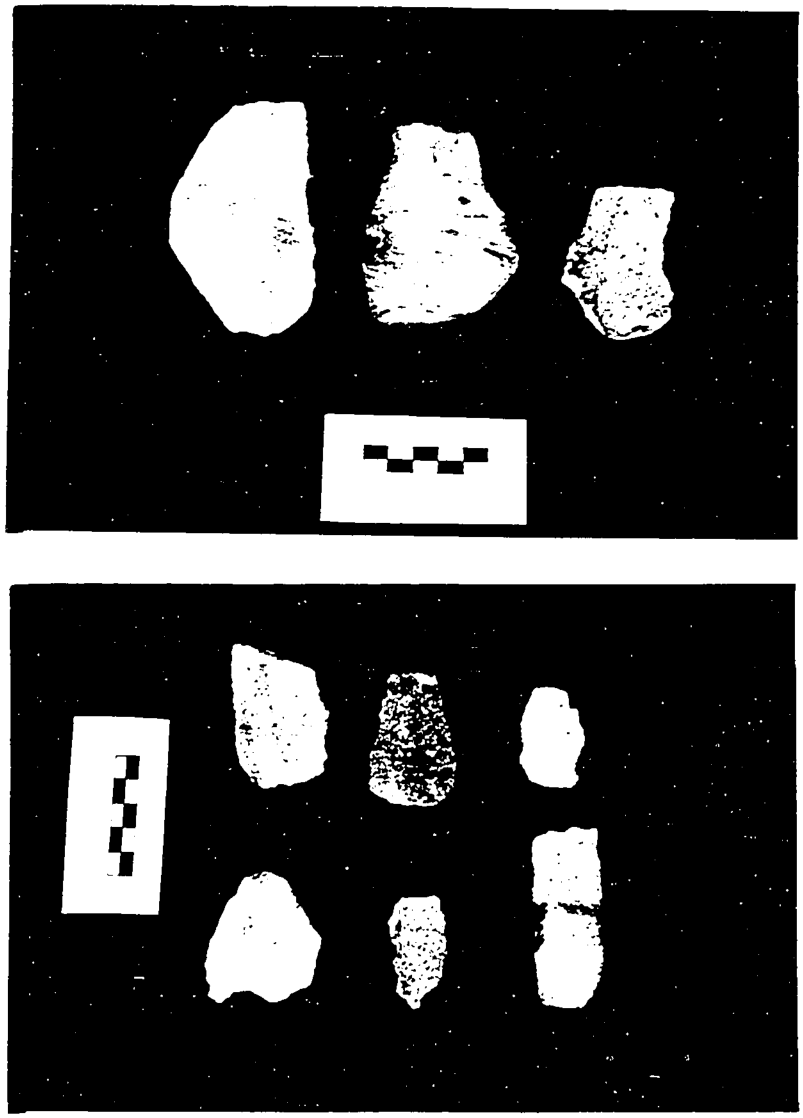


Fig. III 19. Replication: flakes with greater length than width, Shilongtou.



Fig. III 20. Replication: large flake (196x340x72 mm.) from Shilongtou.

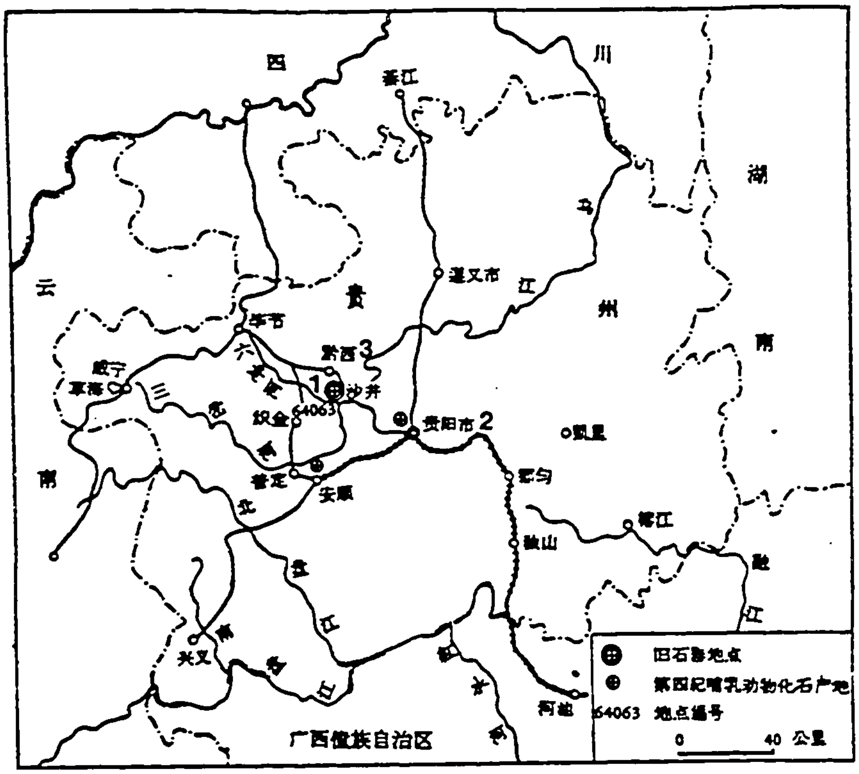


Fig. IV 1. Map of Guanyindong Cave site (Pei, 1965: Fig. 1).
Key: 1. Guanyindong Cave 2. Guiyang city 3. Qianxi county

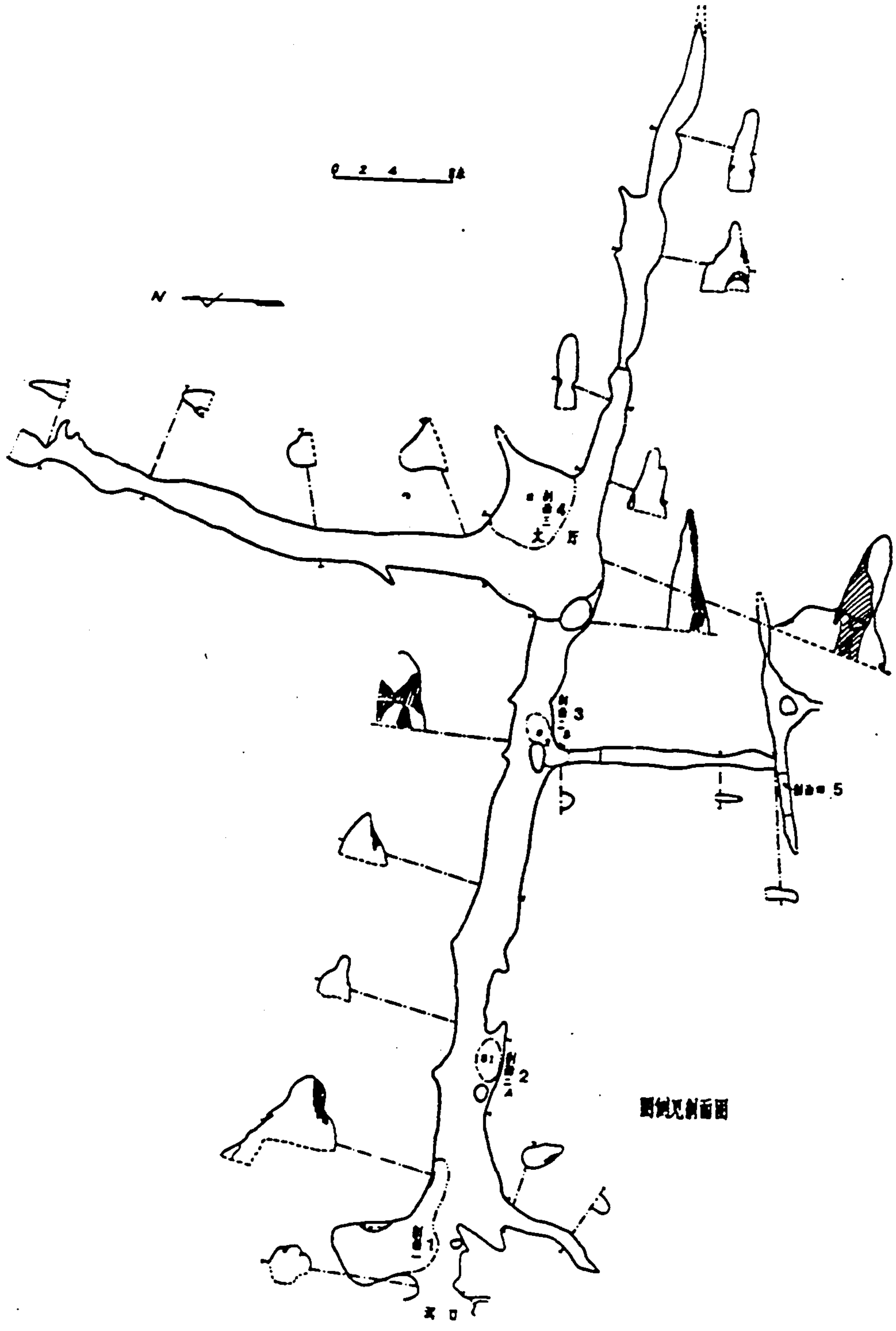


Fig. IV 2. Plan view of the Guanyindong Cave site (Pei, 1965: Fig. 2). Key: 1. Section 1: west mouth 2. Section 2 3. Section 3 4. Section 4 5. Section 5

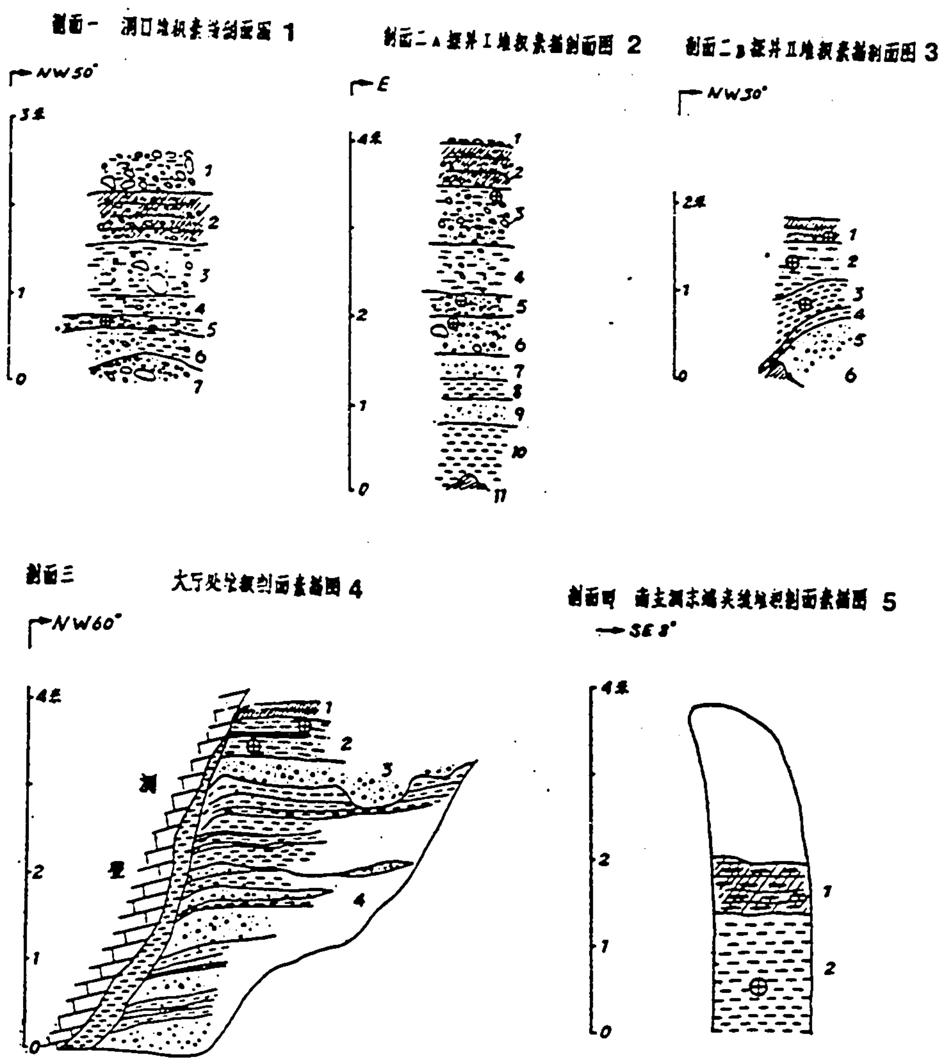


Fig. IV 3. The stratigraphy of the five test excavations at Guanyindong Cave site (Pei, 1965: Fig. 3) Key: 1. Section 1 2. Section 2 3. Section 3 4. Section 4 5. Section 5

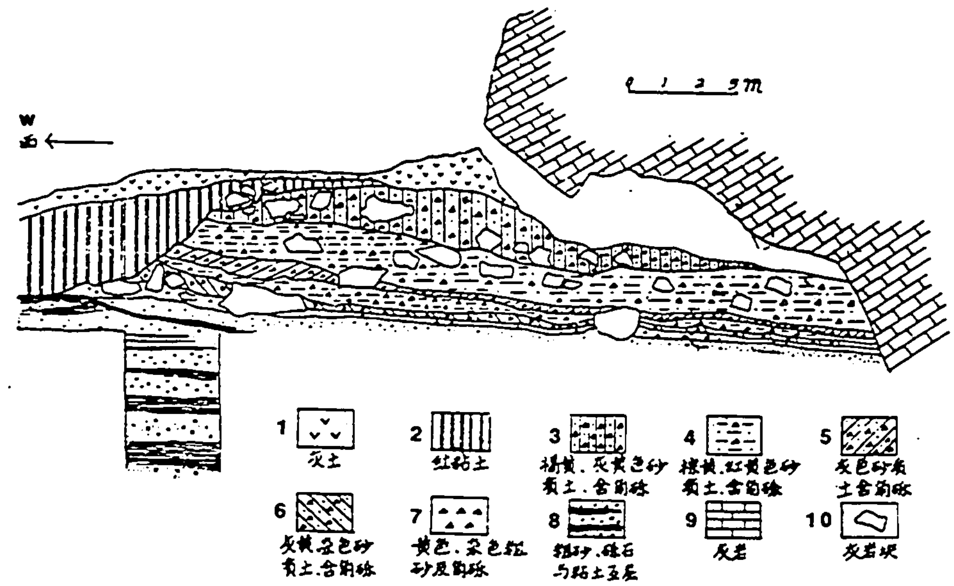


Fig. IV 4. The stratigraphy of the west entrance at Guanyindong Cave site (Li, 1986: Fig. 3) Key: 1. Black sandy clay 2. Red clay 3. Brown yellow, or gray yellow loose sandy clay with limestone blocks and pebbles 4. Brown yellow, or red yellow sandy clay with limestone blocks and pebbles 5. Grey sandy clay with limestone pebbles 6. Brownish yellow or reddish yellow sandy clay 7. Gray or yellow, variegated sandy clay with limestone pebbles 8. Yellow, variegated rough sand with limestone pebbles and blocks 9. Limestone 10. Limestone block

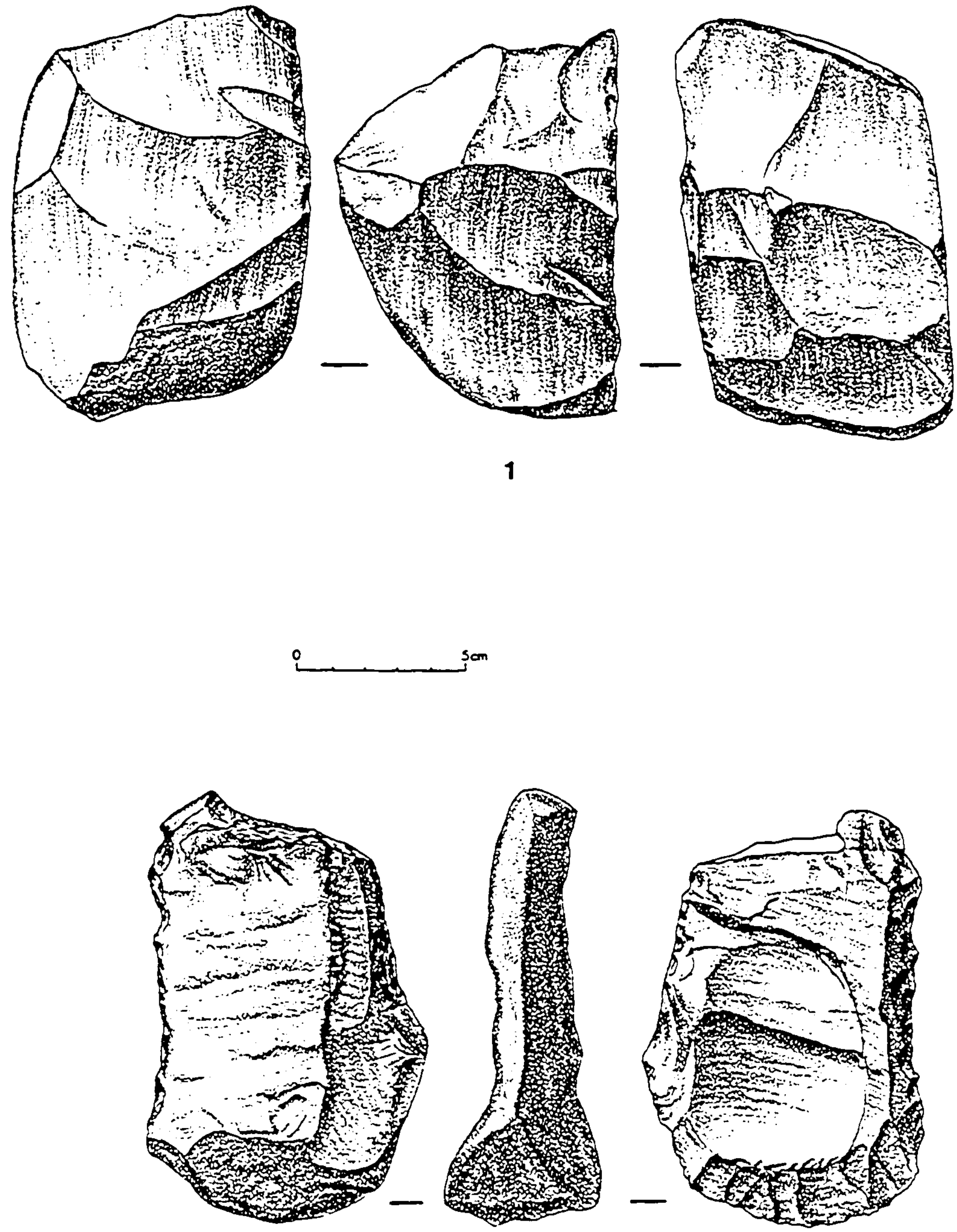


Fig. IV 5. Tools of type C8 (1. P4119 2. P4118) from Guanyindong.

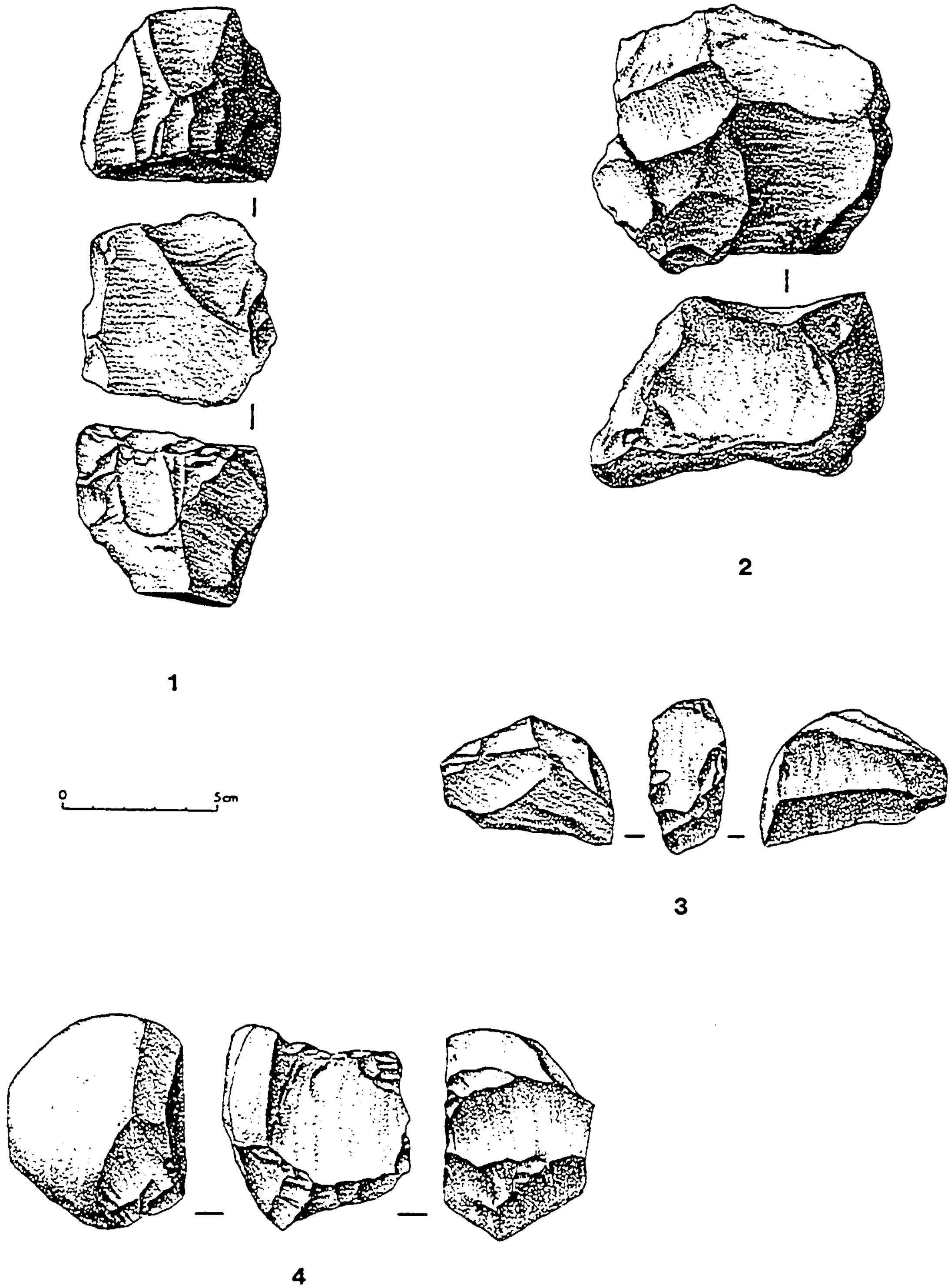


Fig. IV 6. Tools of type C8 (1. P4117 2. P4114 3. P5255 4. P4116) from Guanyindong.

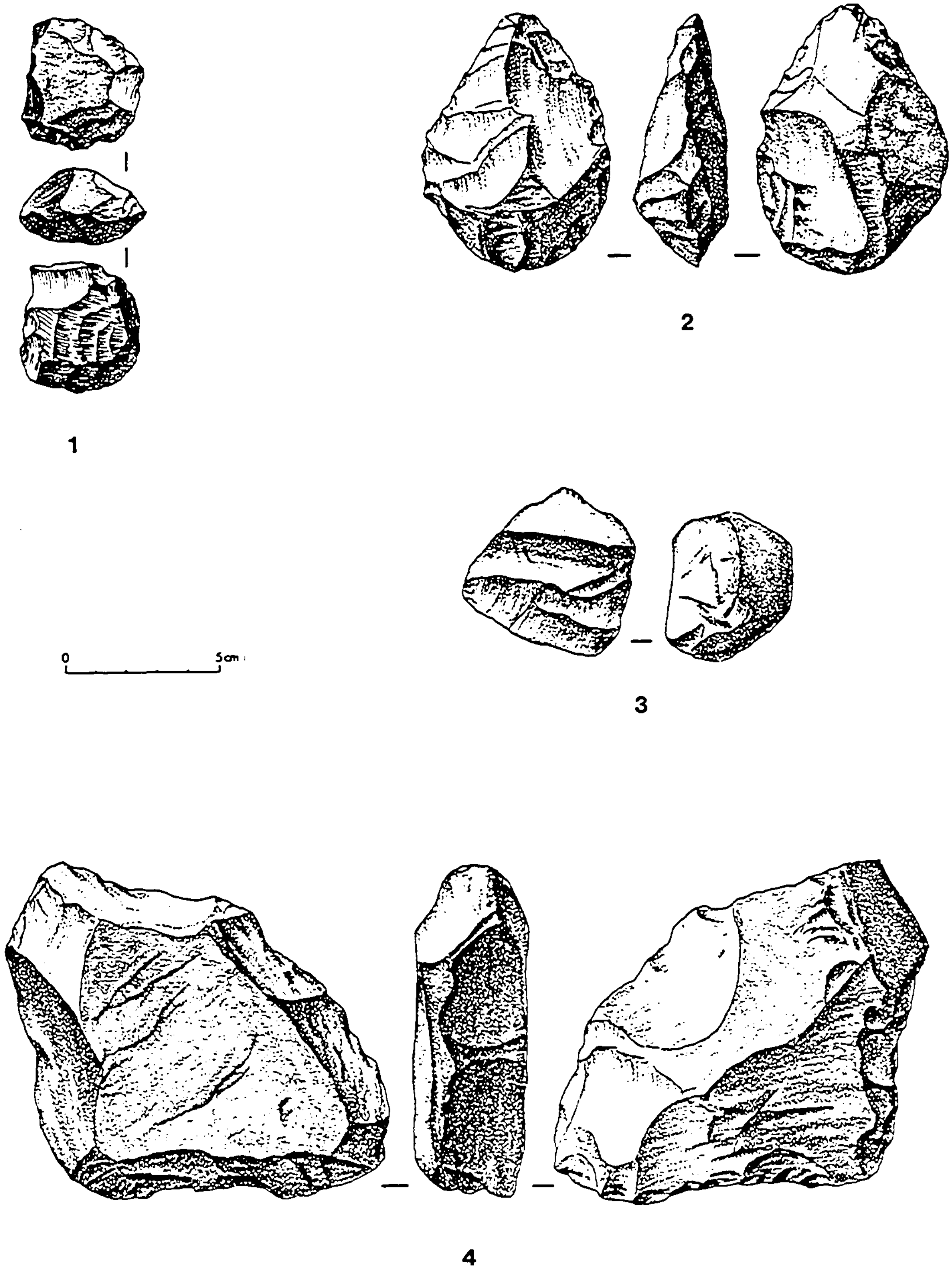


Fig. IV 7. Tools of type C11 (1. P5292), C13 (2. P4266), C17 (3. P4115) and C15 (4. P5266) from Guanyindong.

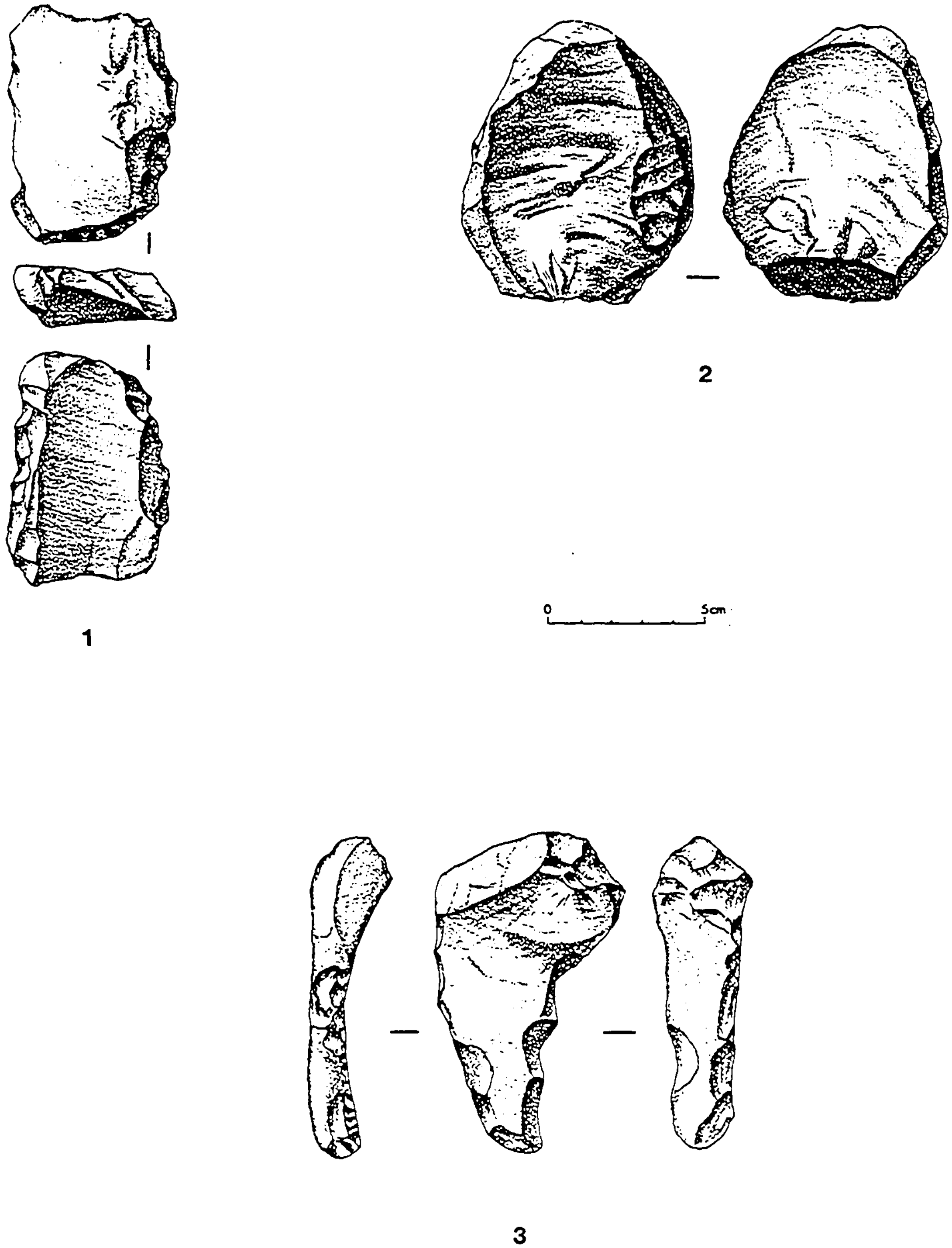


Fig. IV 8. Tools of type F3 (1. P5289) and F2 (2. P3957 3. P5271) from Guanyindong.

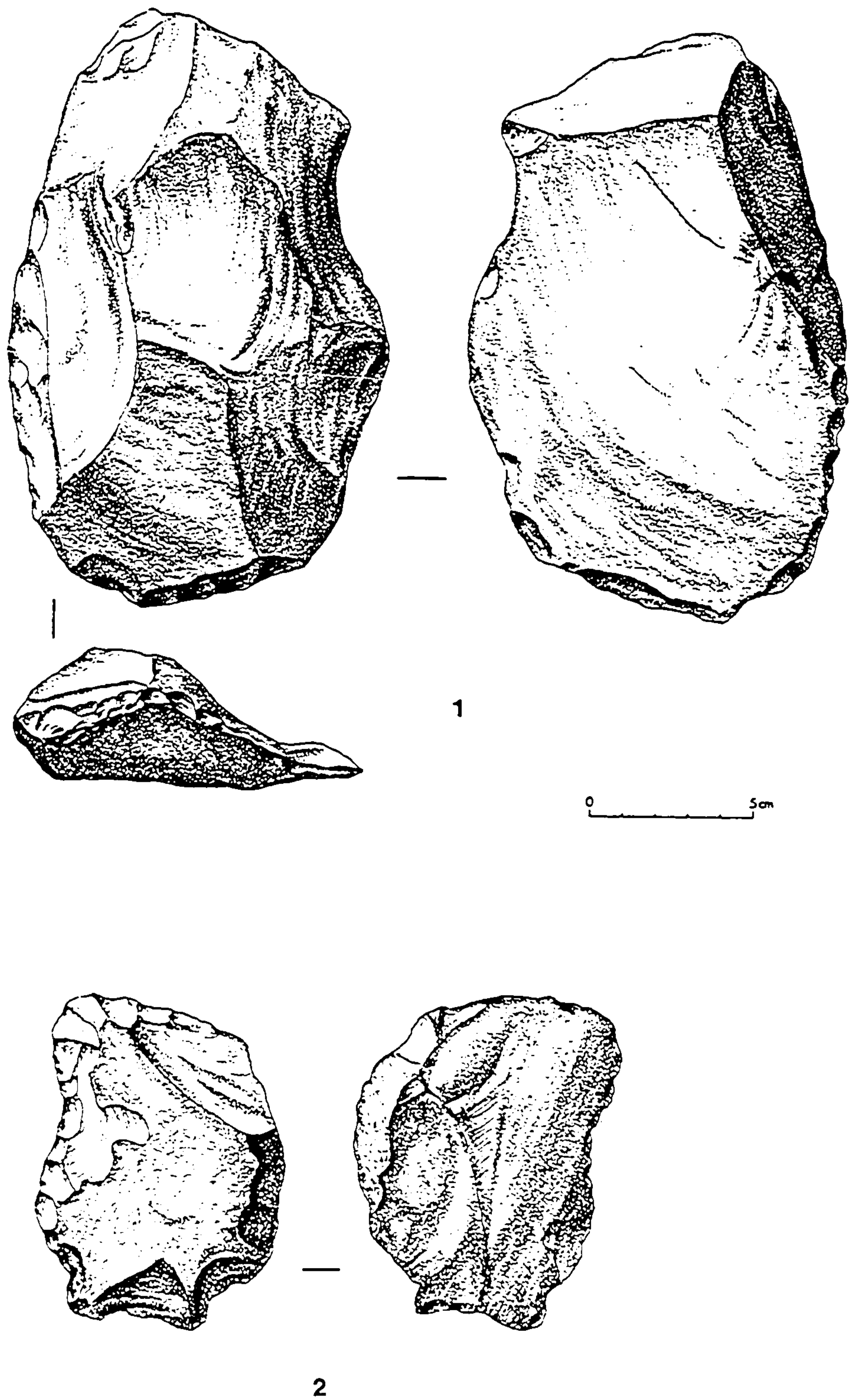


Fig. IV 9. Tools of type F3 (1. P4261 2. P4276) from Guanyindong.

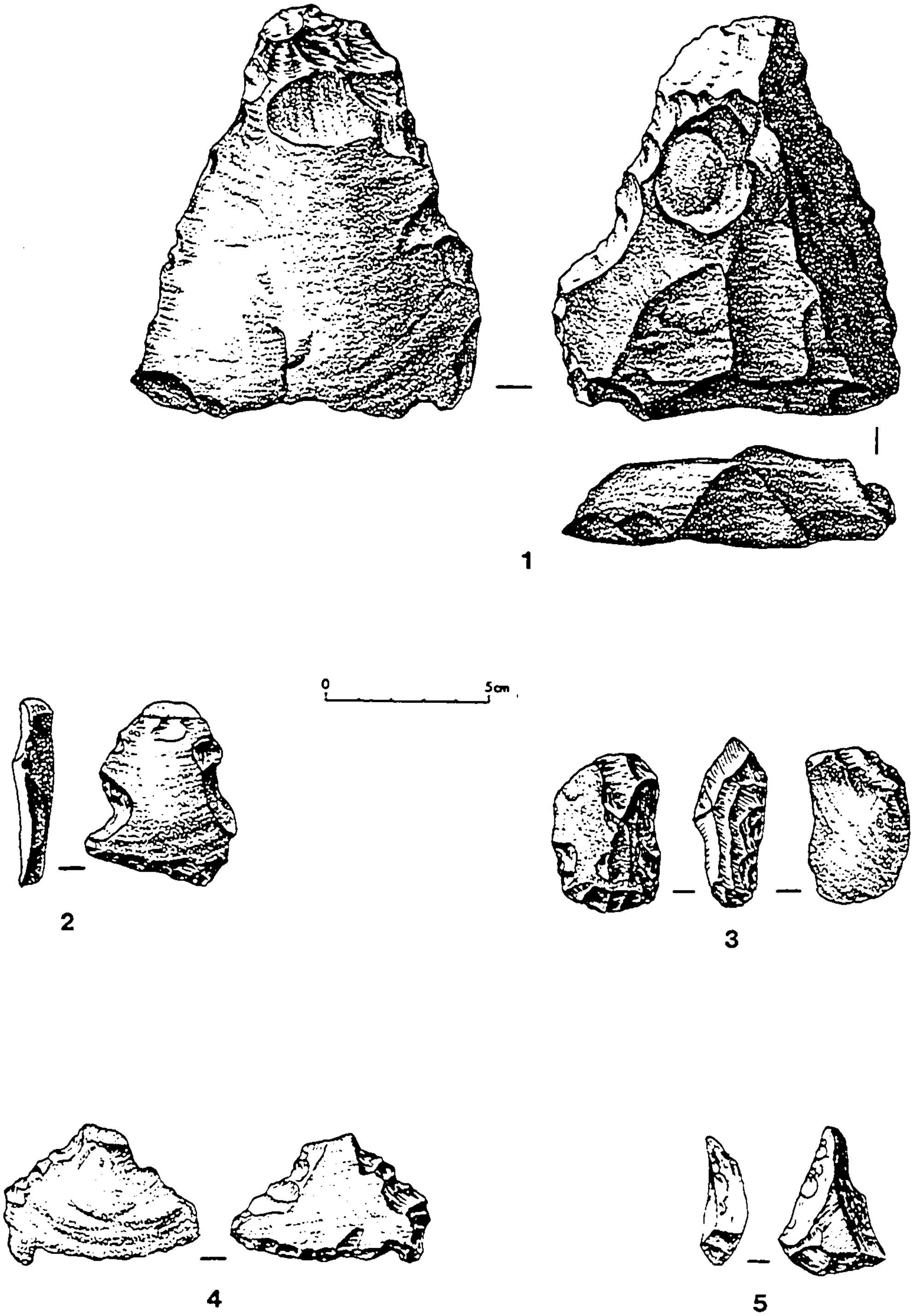


Fig. IV 10. Tools type of F3 (1. P4274 2. P5366 3. P5354 4. P5303) and F4 (5. P5299) from Guanyindong.

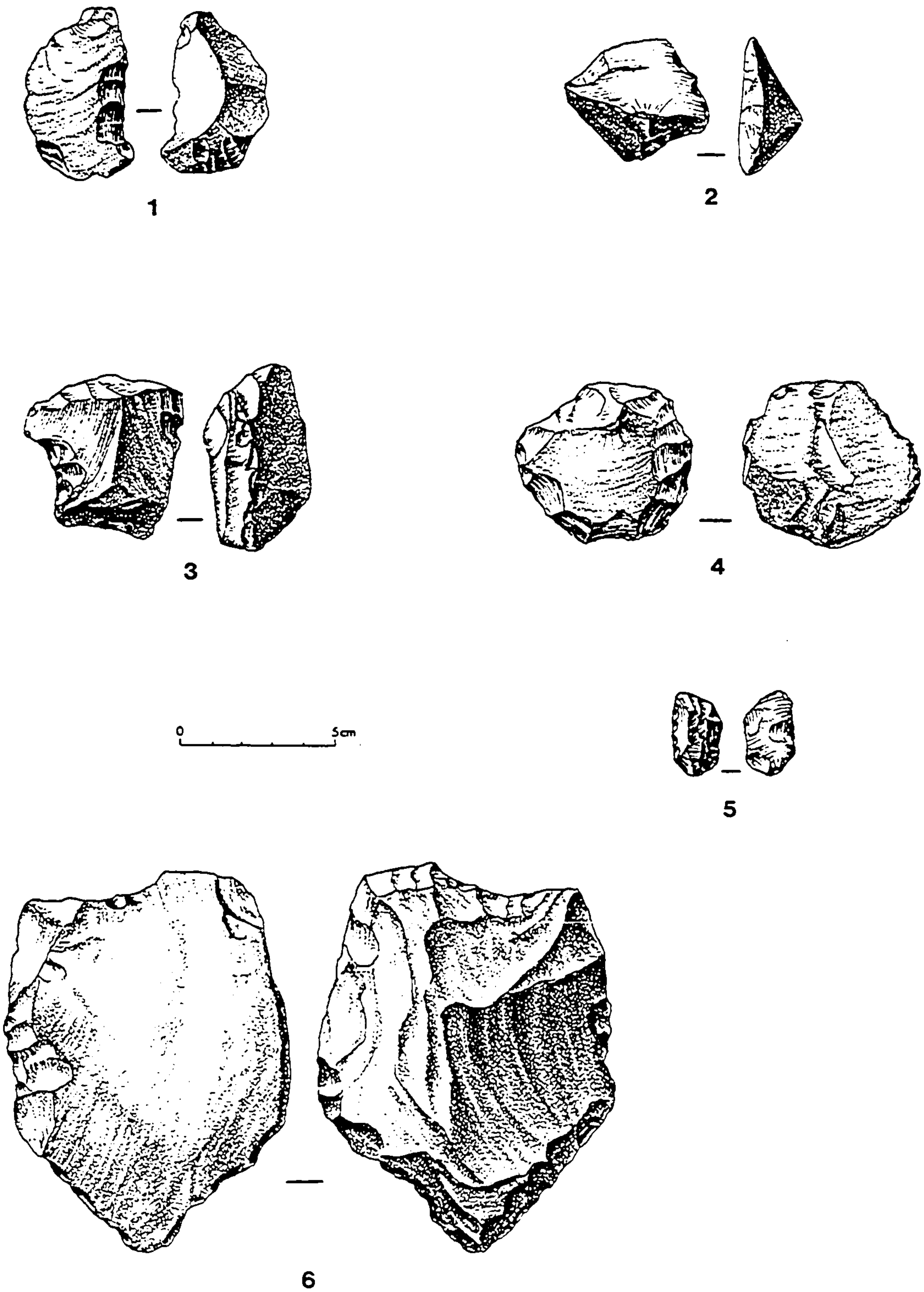


Fig. IV 11. Tools type of F7 (1. P5277), F8 (2. P5258), and F10 (3. P5276 4. P5312 5. P5311 6. P3890) from Guanyindong.

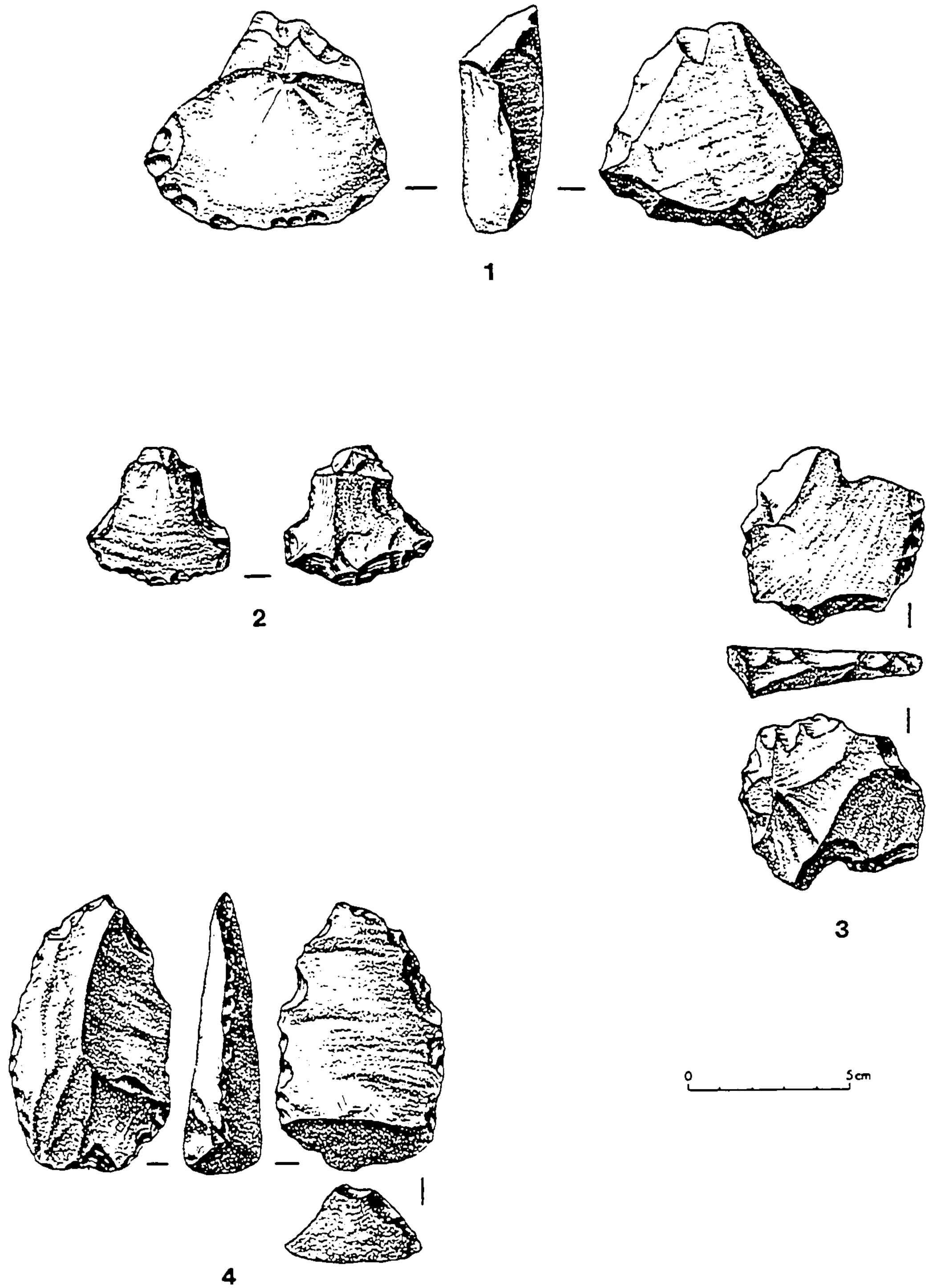


Fig. IV 12. Tools type of F14 (1. P3951 3. P5367), F20 (2. P5297) and F15 (4. P3907) from Guanyindong.

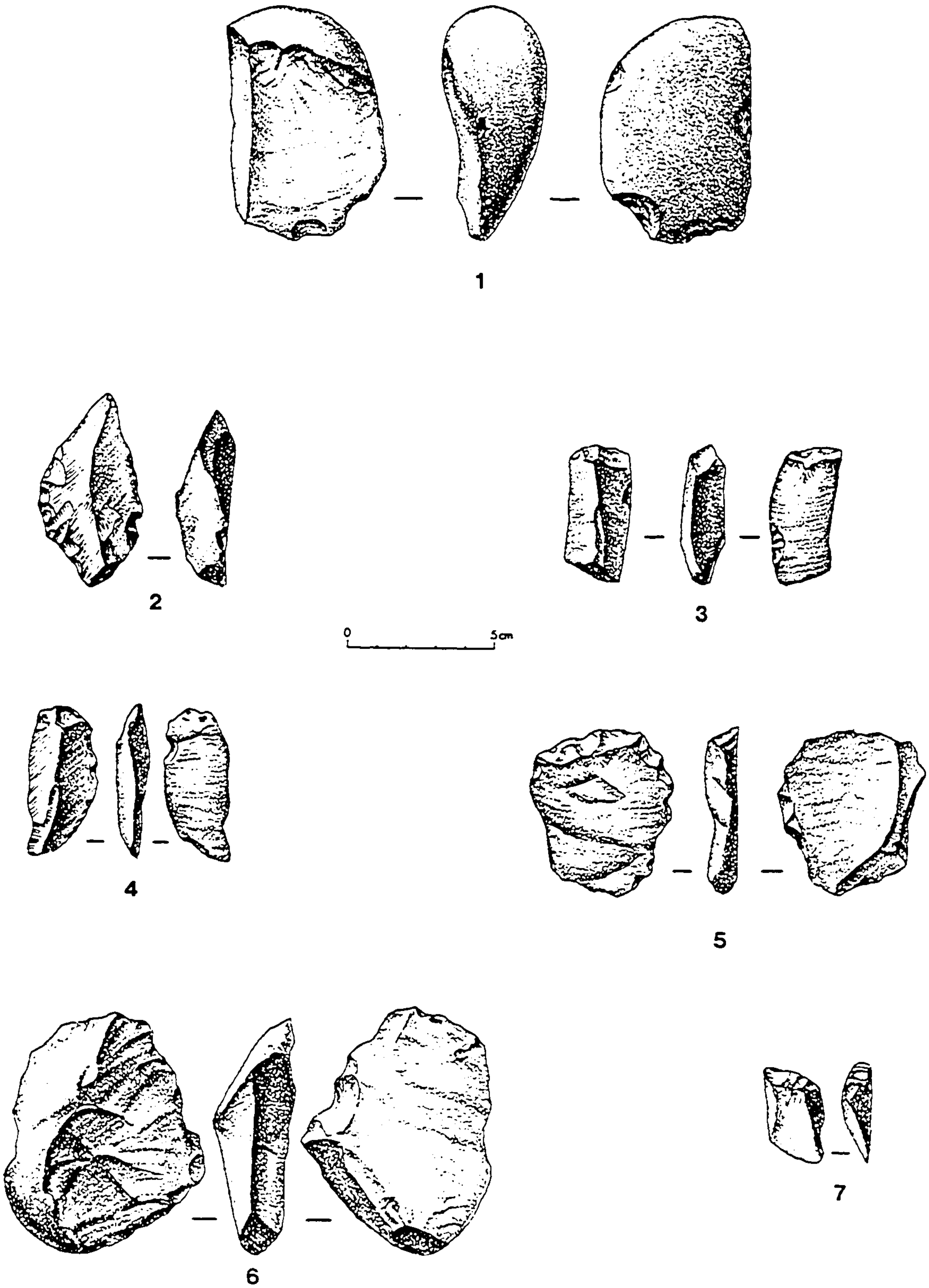


Fig. IV 13. Tools type of U1 (1. P3953 2. P5256 3. P3946 4. P5257 5. P3959 6. P3941 7. P5260) from Guanyindong.

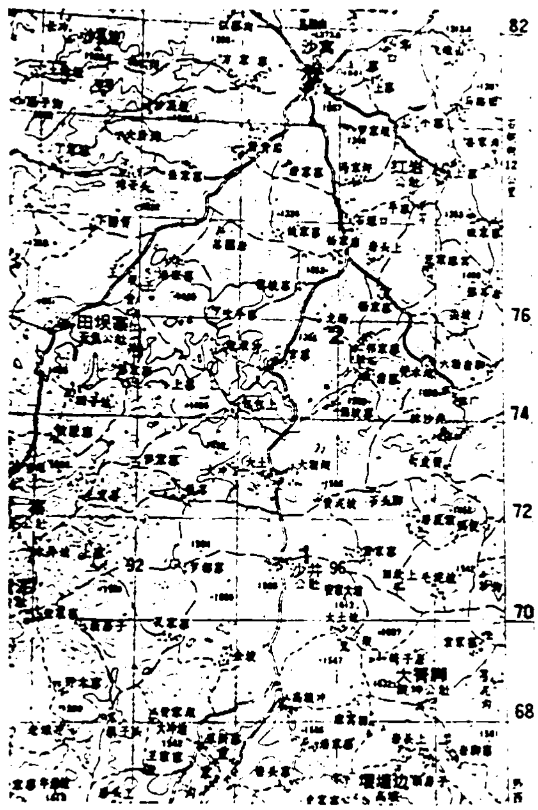


Fig. IV 14. The location of Jinyan hill. Key: 1. Guanyindong Cave site 2. Jinyan hill



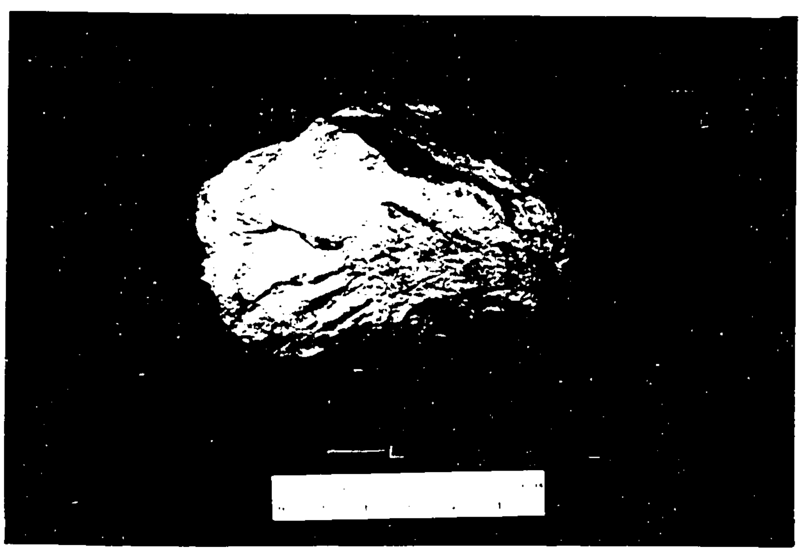


Fig. IV 15. Chert nodules (av. nodule size 170x130x101 mm.) used in the replicative studies at Guanyindong (below: 15 cm scale).

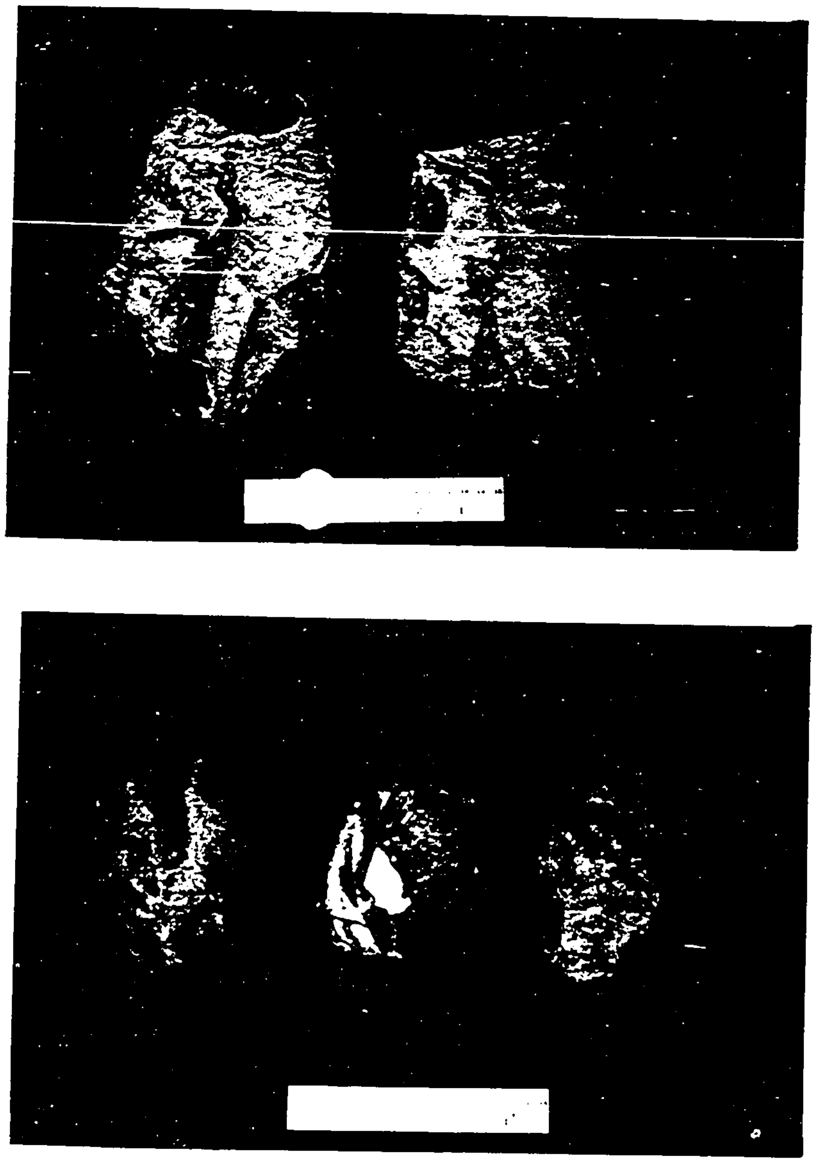


Fig. IV 16. Chert nodules used in the replicative studies at Guanyindong (15 cm. scale).

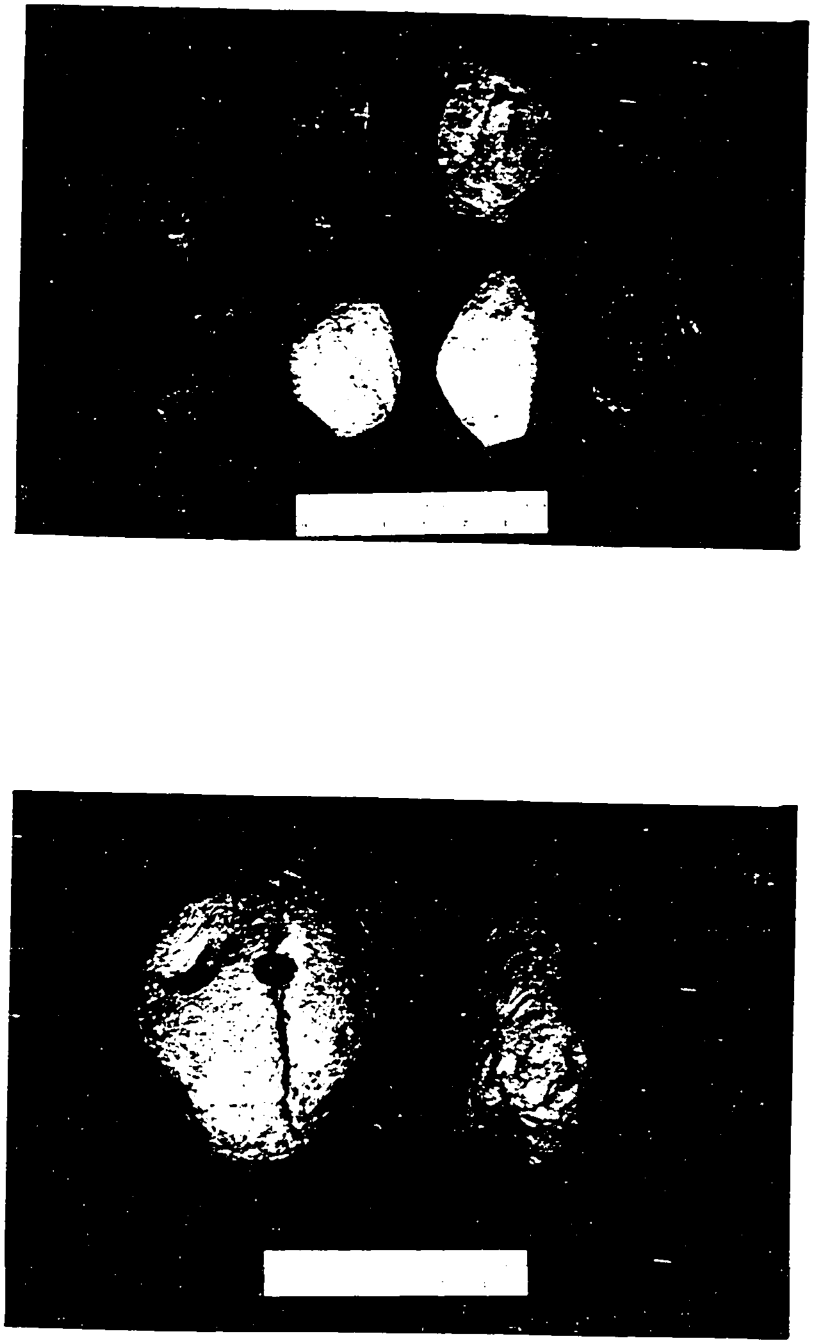


Fig. IV 17. Hammerstones used in the replicative studies, Guanyindong (15 cm. scale).

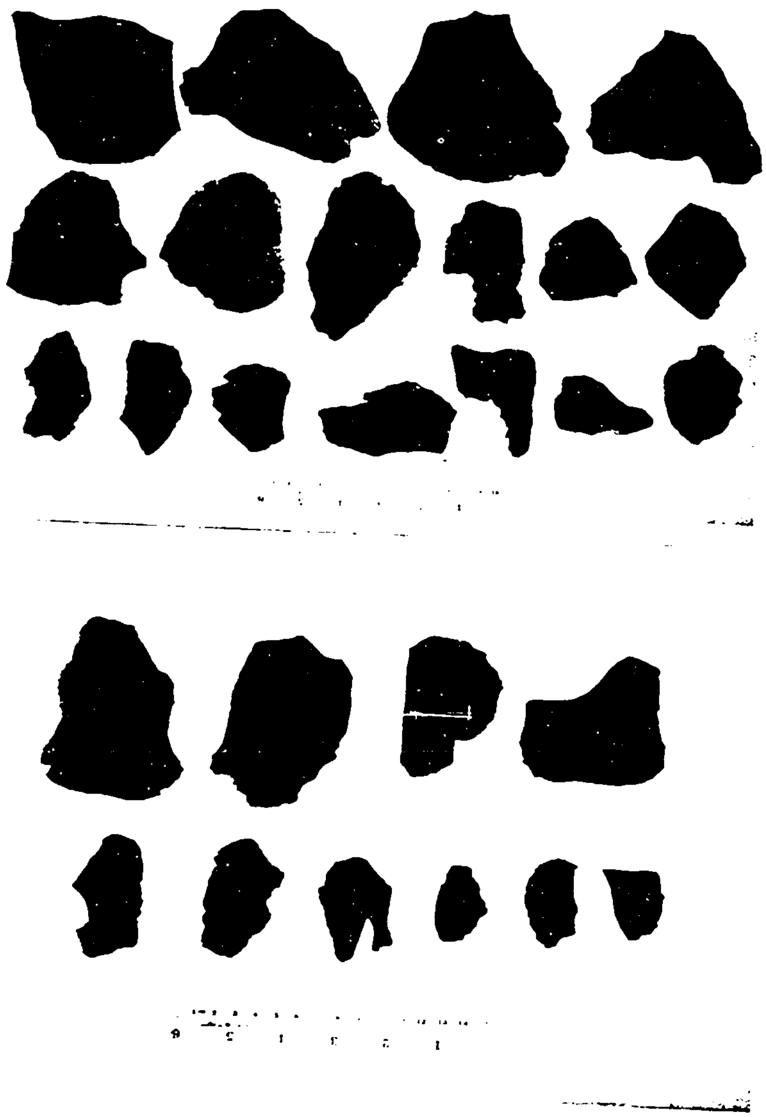


Fig. IV 18. Replication: flakes are produced by a roughing-out step from the chert nodules, Guangyindong.

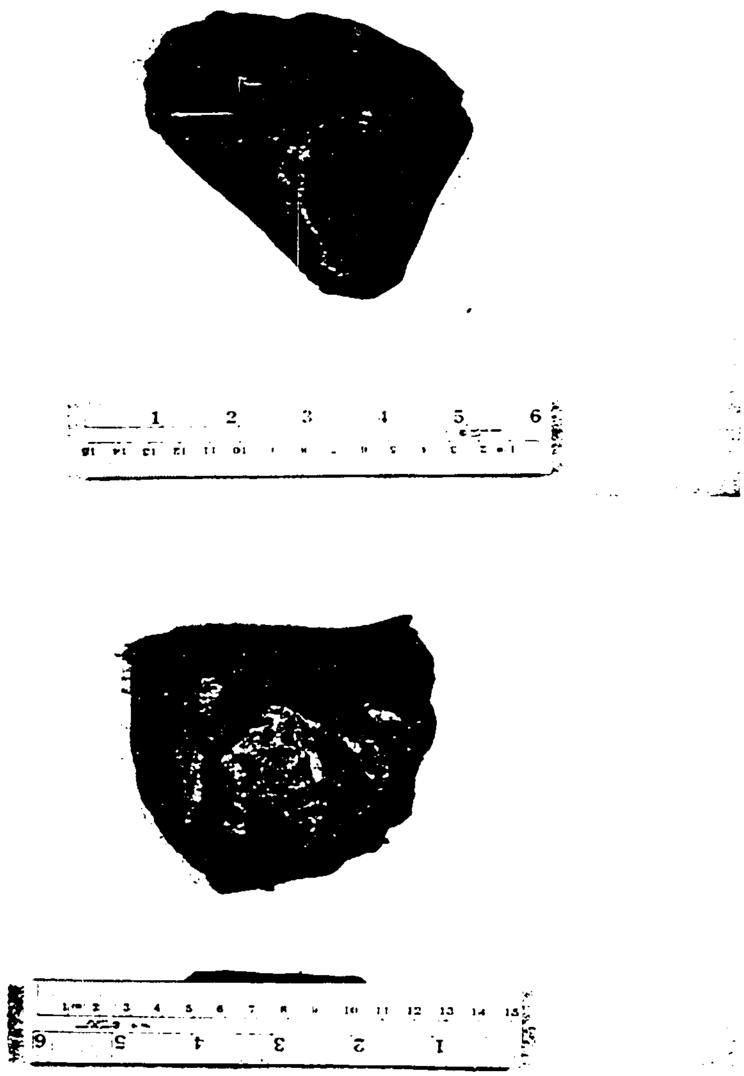
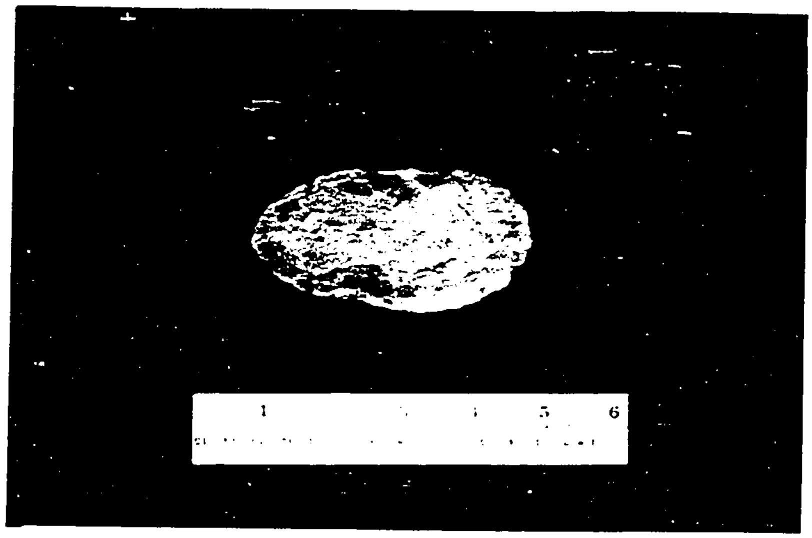


Fig. IV 19. Replication: flakes refitted to the core at Guanyindong.



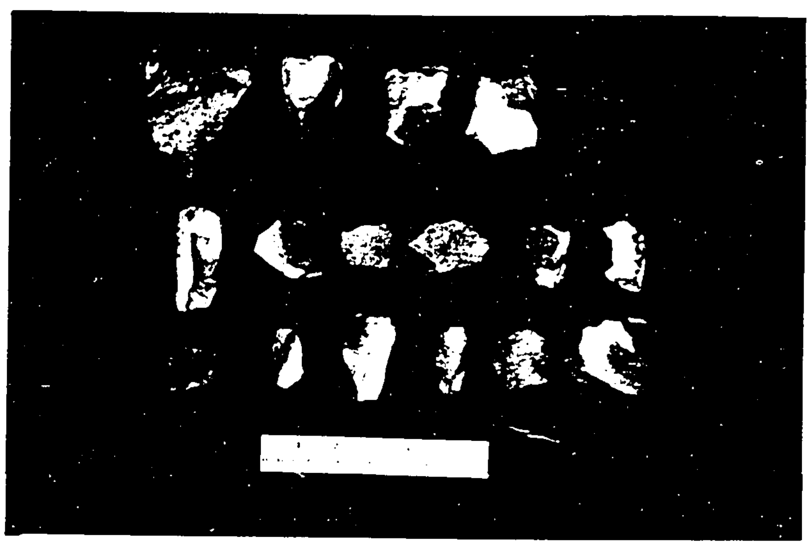
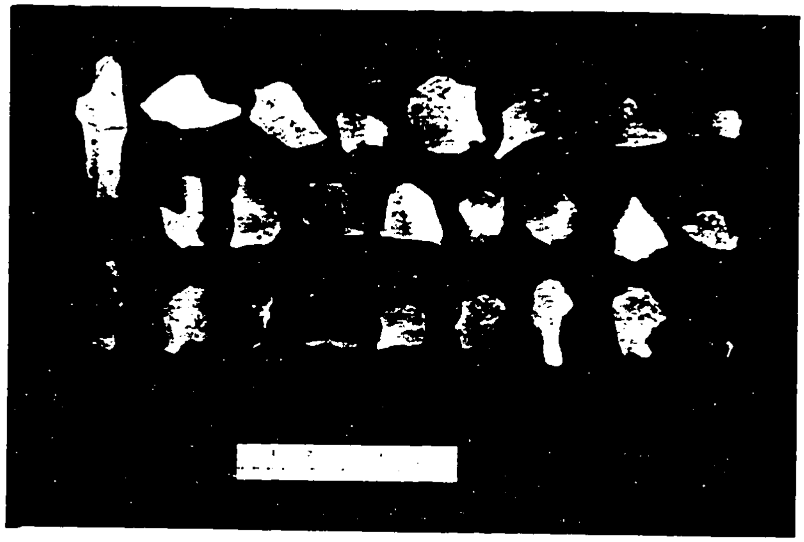


Fig. IV 20. Replication: C13, of Guanyindong.



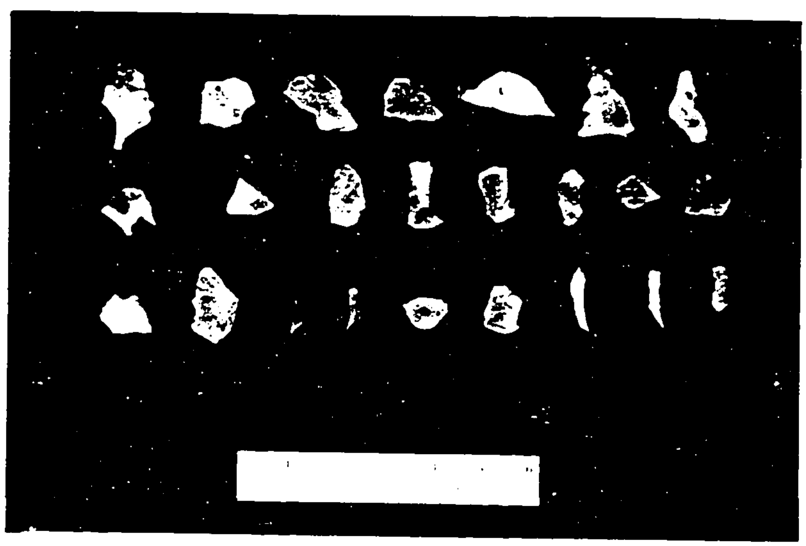


Fig. IV 21. Replication: flakes are produced by the thinning and shaping steps at Guanyindong.

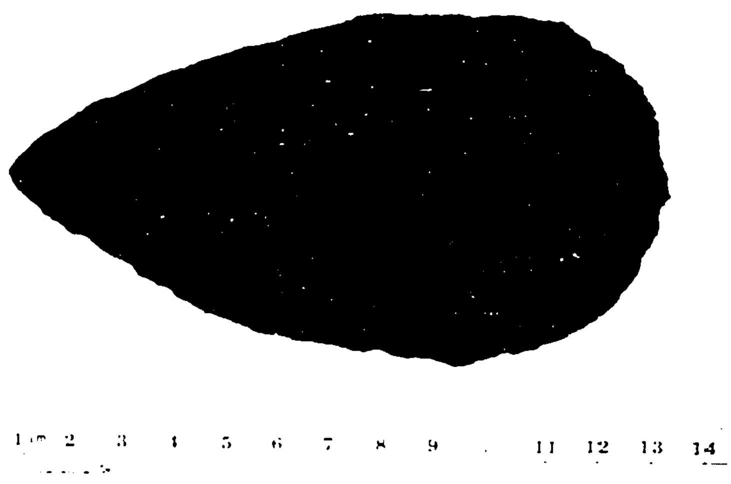


Fig. IV 22. Replication: C13, of Guanyindong.

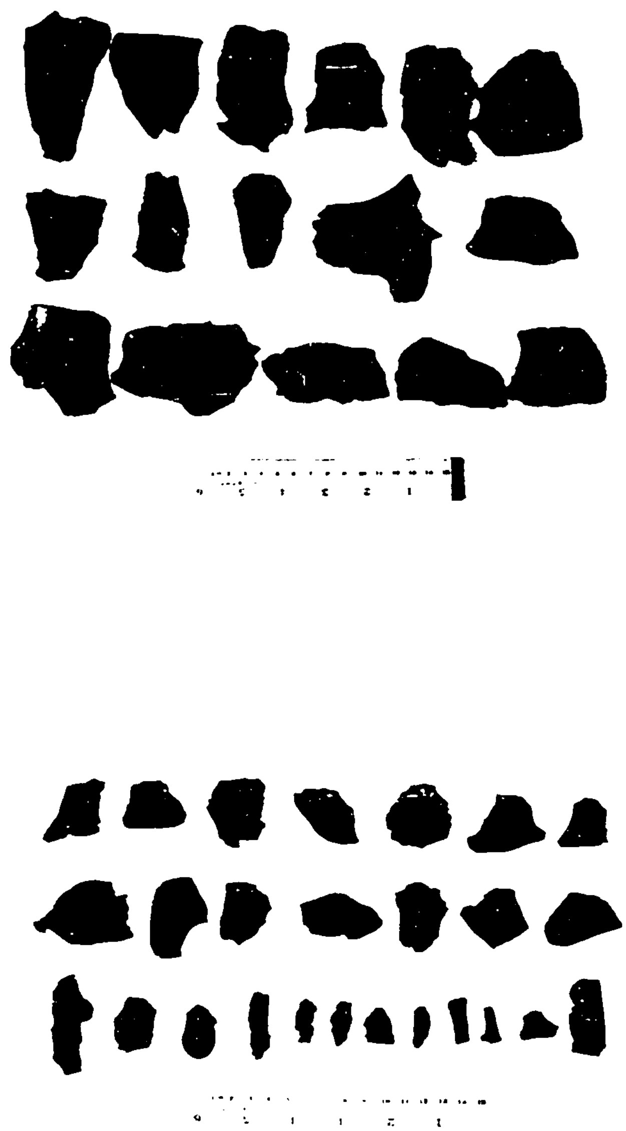


Fig. IV 23. Replication: flakes are produced from replication C13 at Guanyindong on Fig. IV 22.

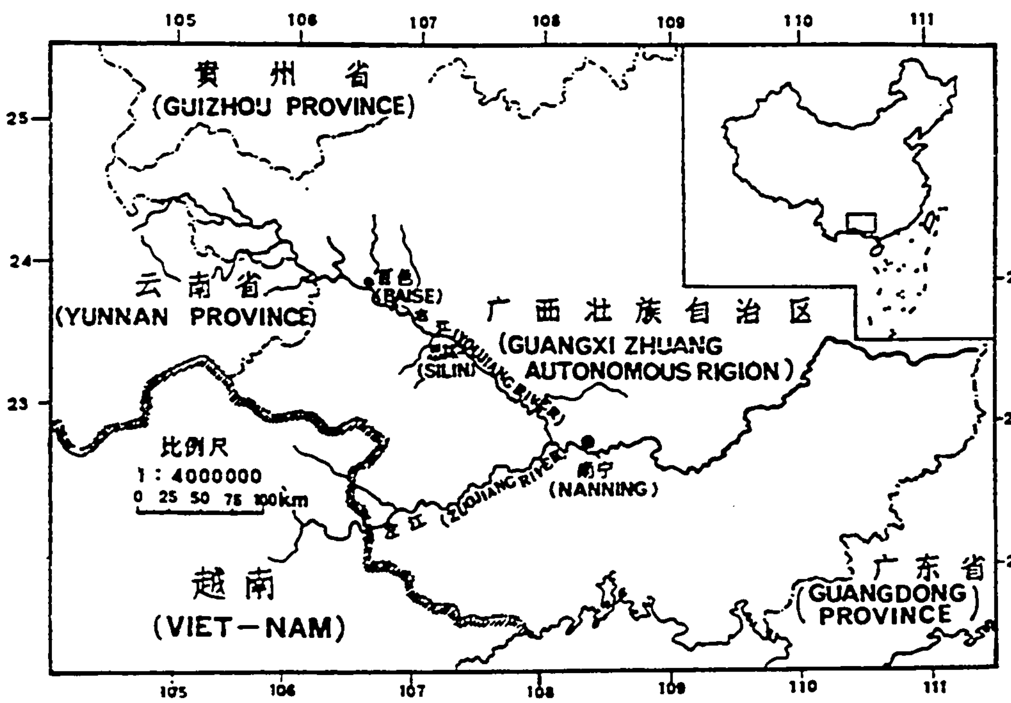


Fig. V 1. Geographical location of Bose site (Huang, 1990: Fig. 1). Key: Baise is Bose.



Fig. V 2. The You River passes through the central part of the Bose Basin.

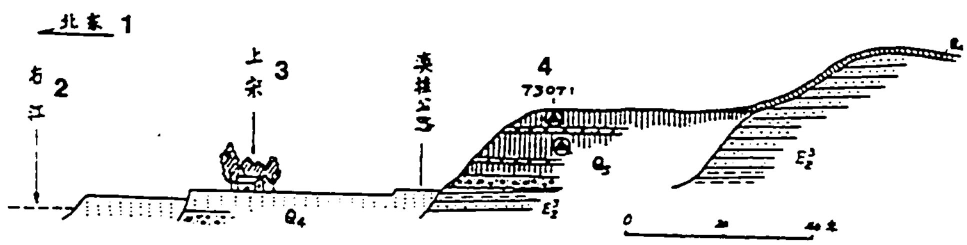


Fig. V 3. The section of Bose site at Shangsong village (Li, 1975: Fig. 1). Key: 1. NE 2. You River 3. Shangsong village 4. Section of the site.

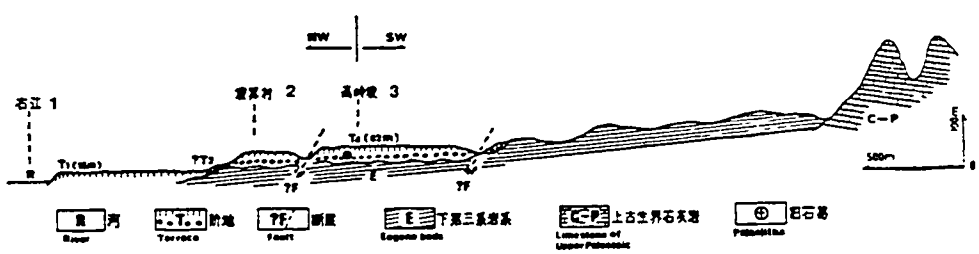


Fig. V 4. The section showing the terraces of Youjiang River near Posuan village (Huang, 1990: Fig. 2). Key: 1. You River 2. Posuan village 3. Gaolingpo hill



Fig. V 5. Bose site at Posuan village.



Fig. V 6. The stratigraphy of Bose site at Posuan village.

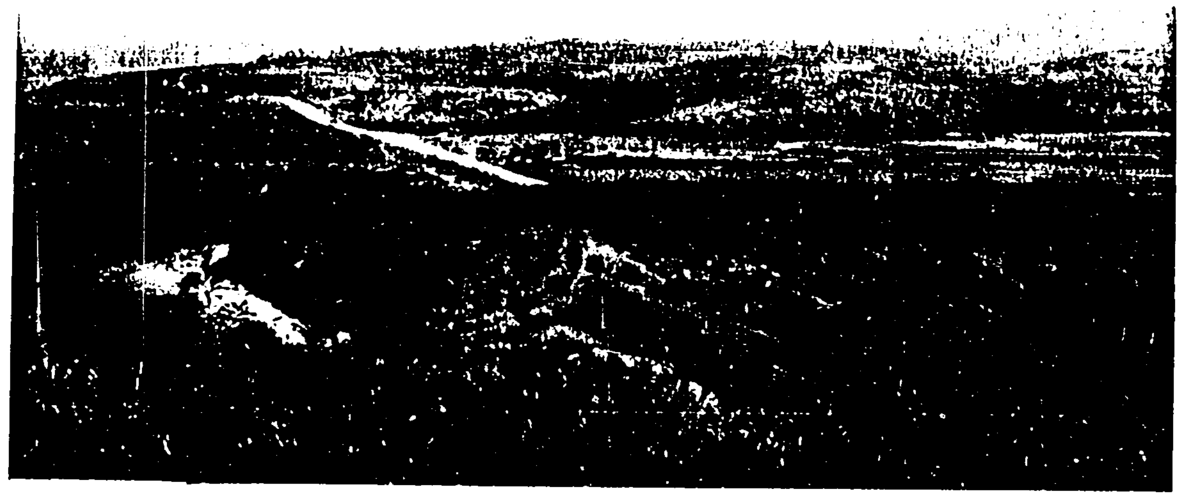


Fig. V 7. A view from Posuan village to You River.

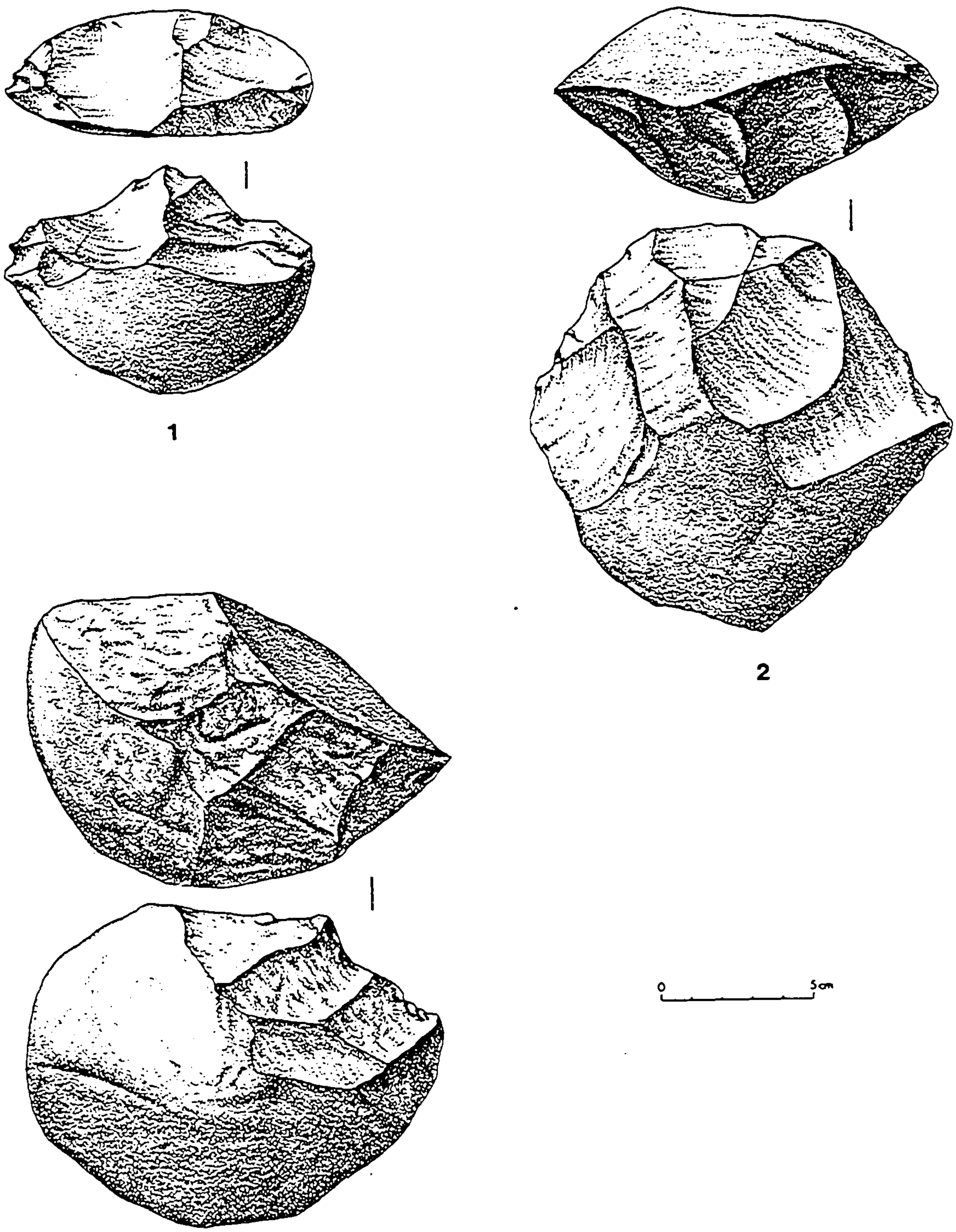


Fig. V 8. Tools of type Cl (1. Chaimu 5 2. Dongzen 3
3. Tanhe 9) from Bose.

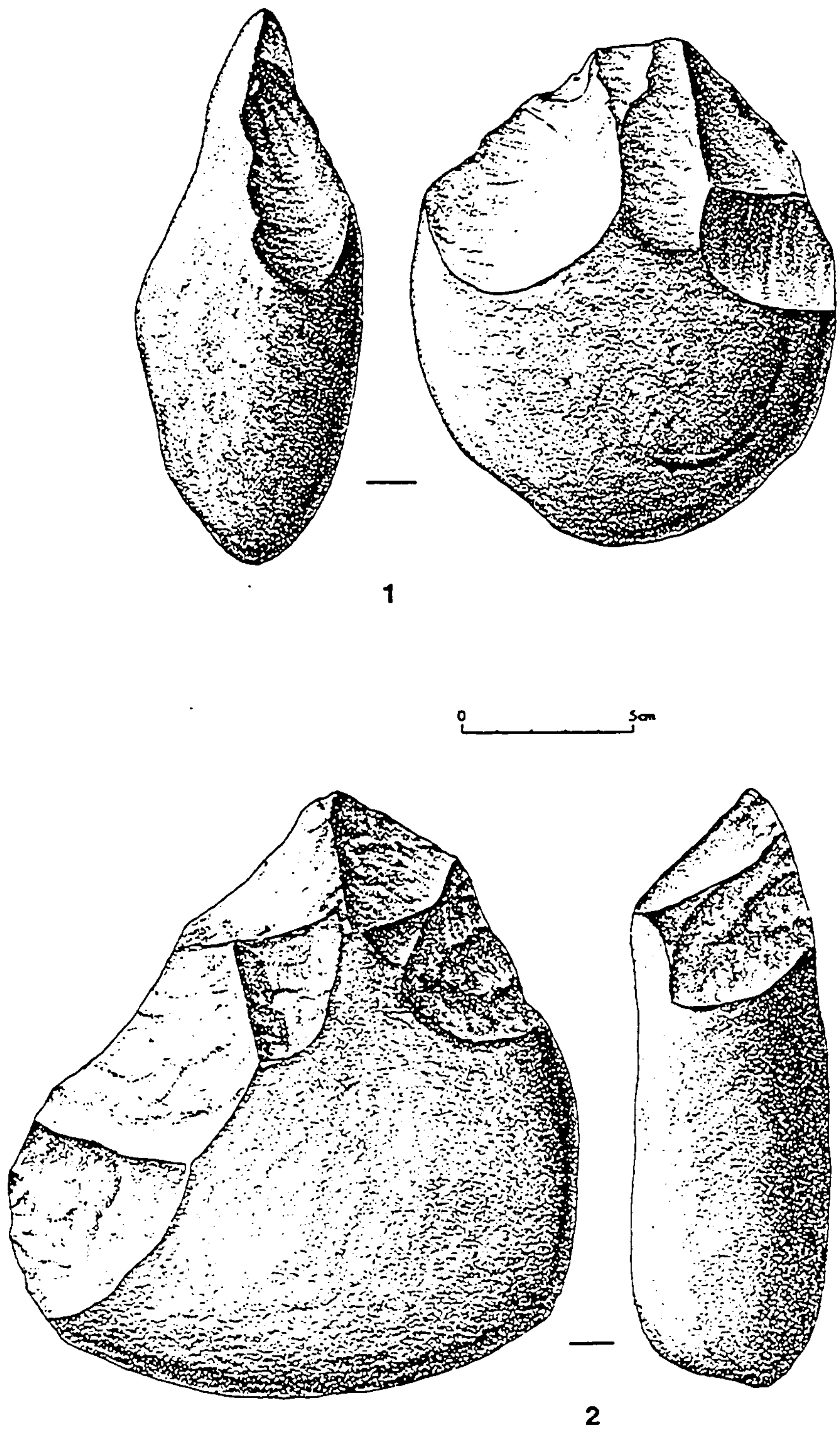


Fig. V 9. Tools of type C1 (1. Tanhe 5) and C2 (2. Dongzen 4) from Bose.

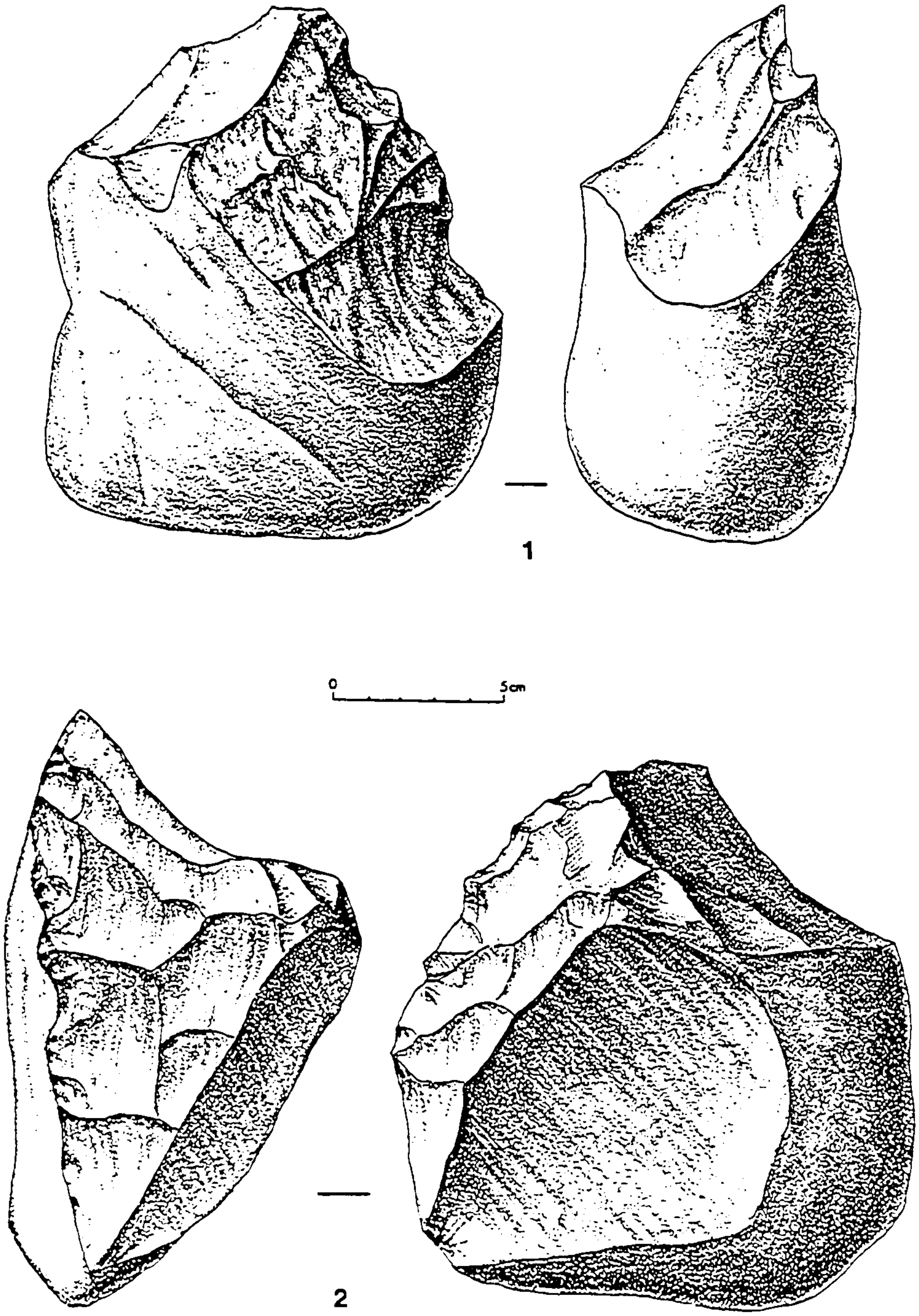


Fig. V 10. Tools of type C2 (1. Chaimu 8) and C3 (2. Chaimu 9) from Bose.

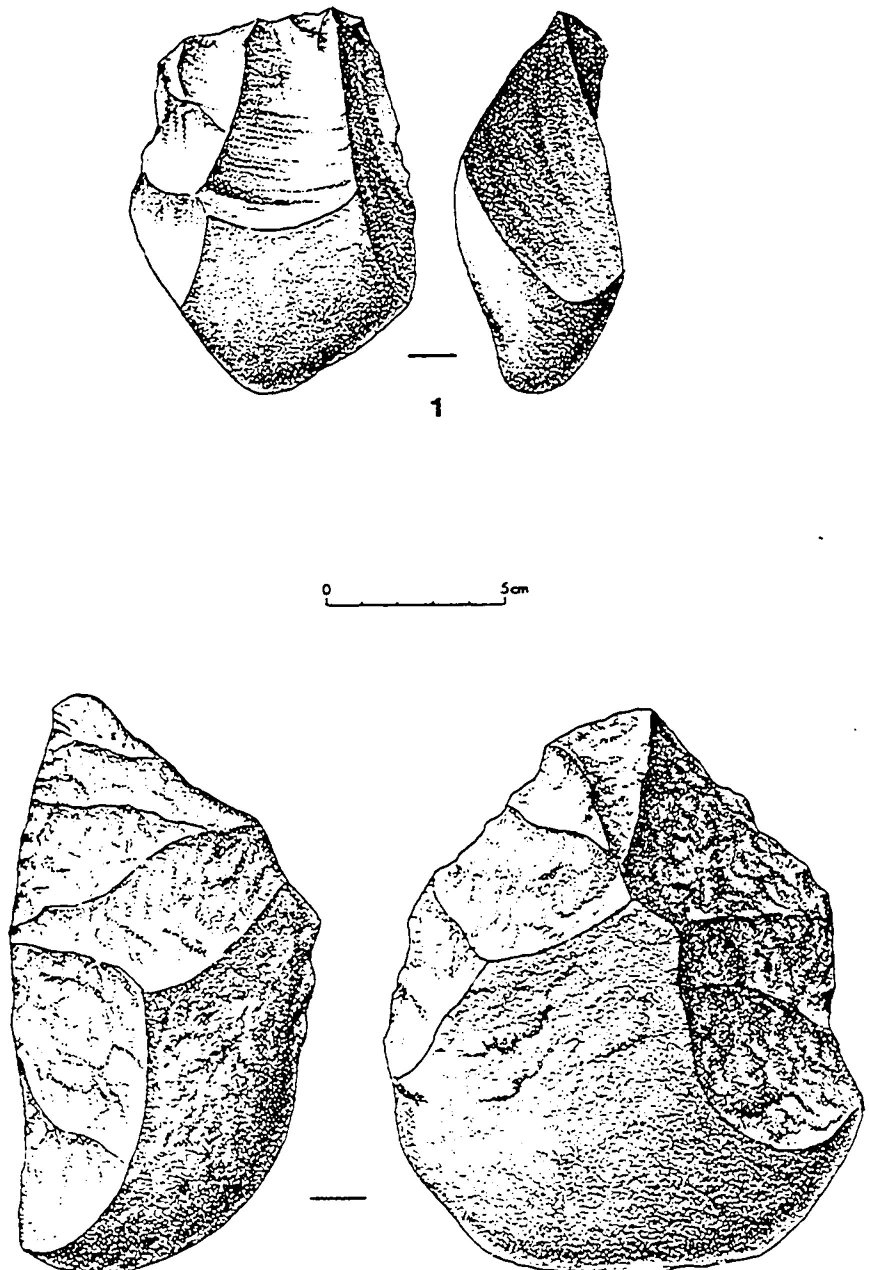


Fig. V 11. Tools of type C3 (1. Chaimu 6) and C5 (2. Shangsong 1) from Bose.

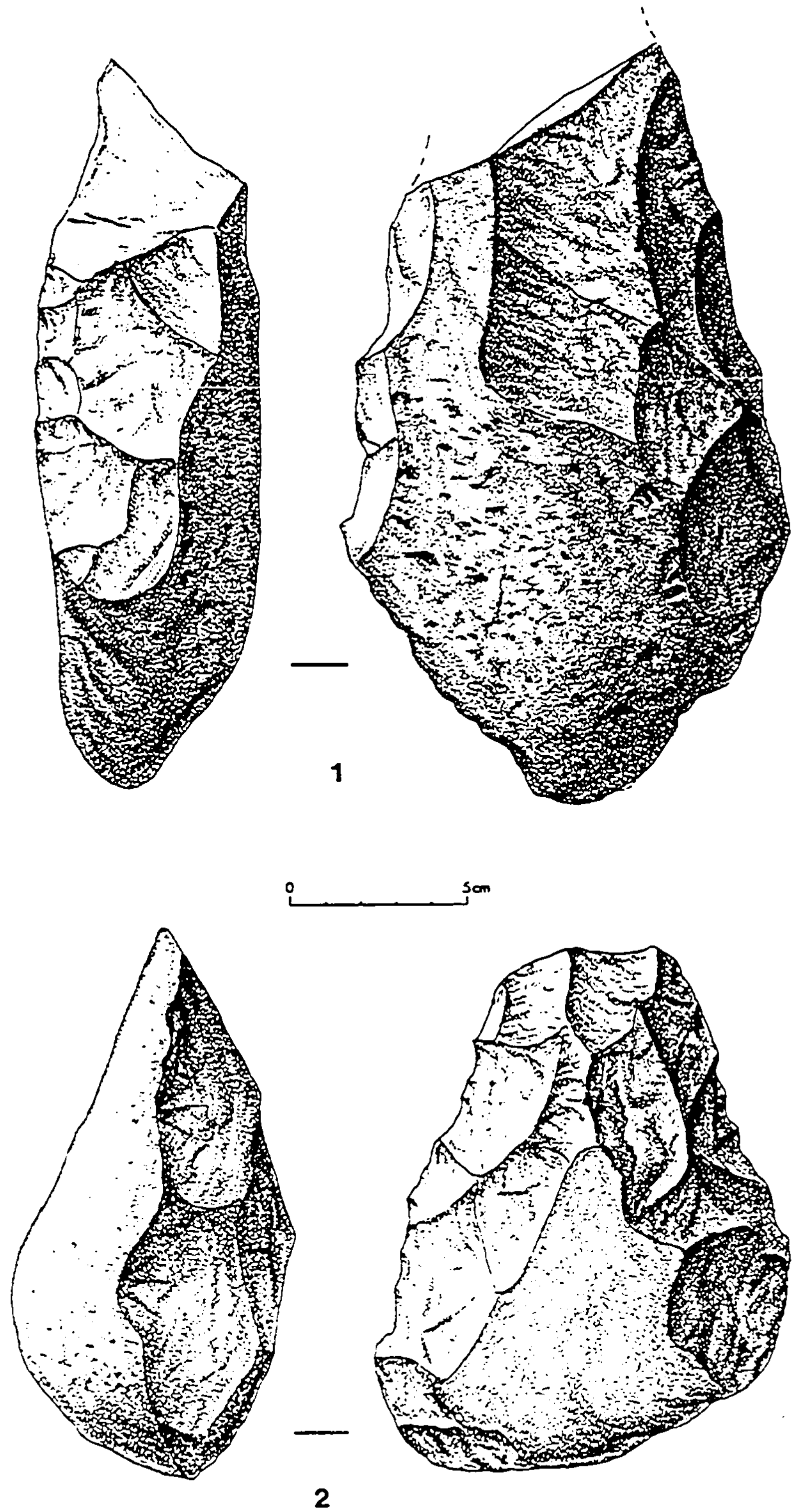
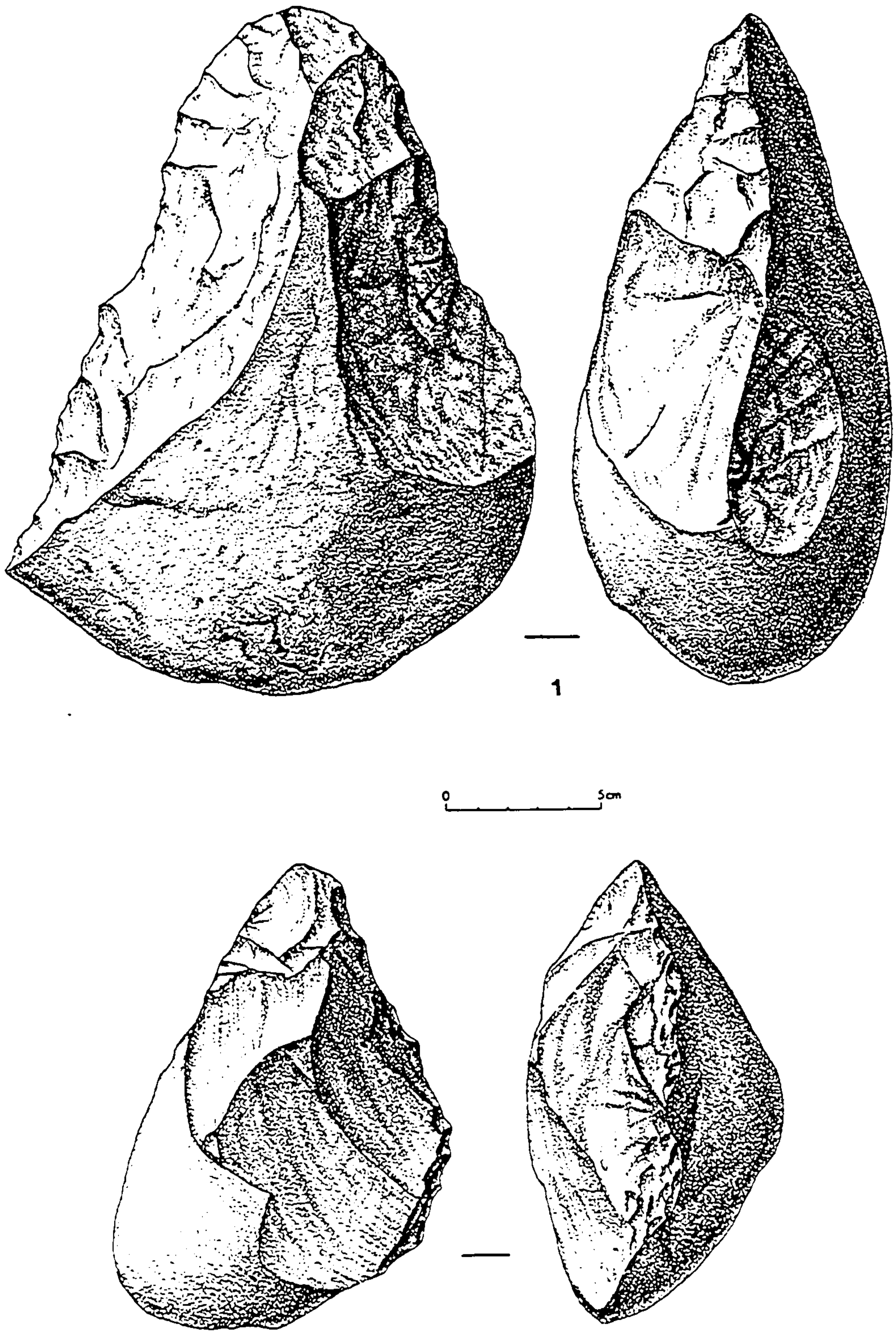


Fig. V 12. Tools of type C5 (1. Damei 072 2. Tanhe 7) from Bose.



2

Fig. V 13. Tools of type C5 (1. Tanhe 10 2. Chaimu 7) from Bose.

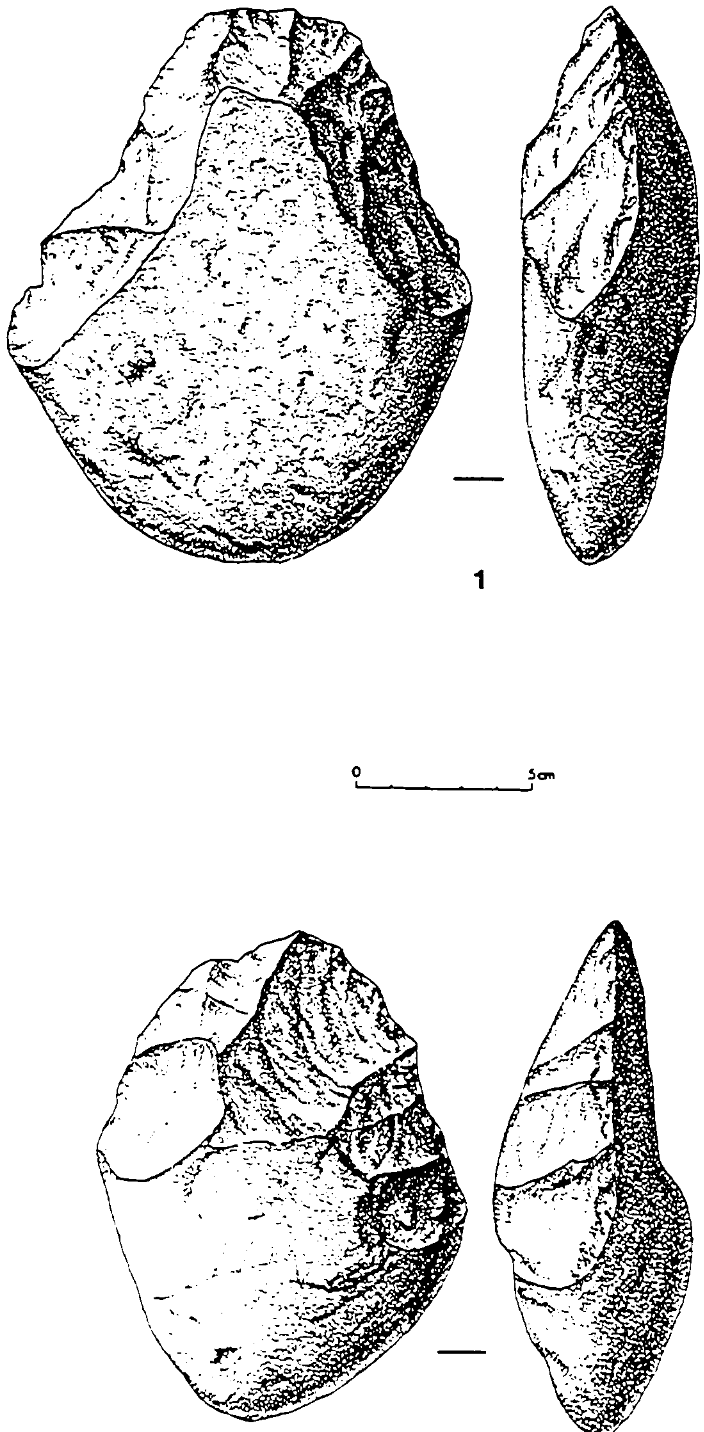


Fig. V 14. Tools of type C5 (1. Tanhe 1 2. Tanhe 8) from Bose.

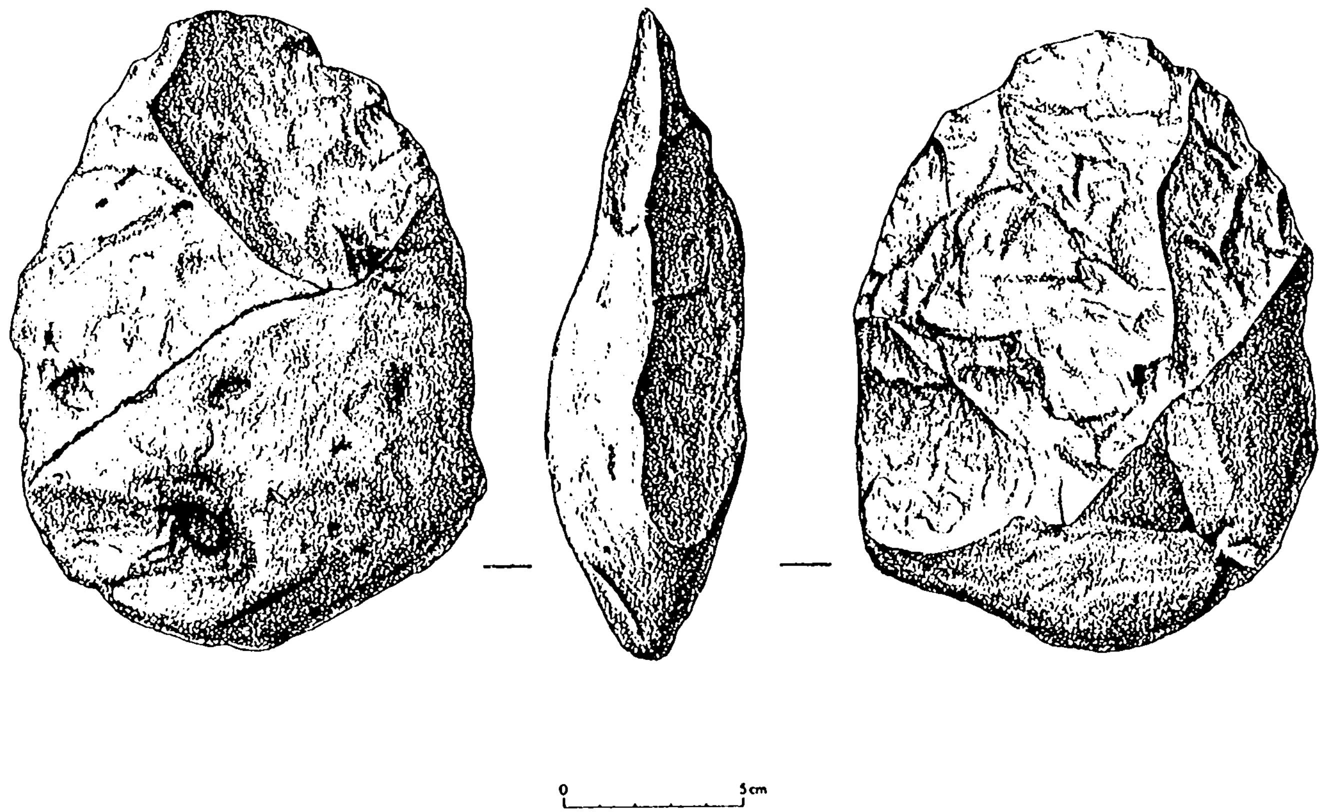


Fig. V 15. Tool of type C5 (Damei 096) from Bose.

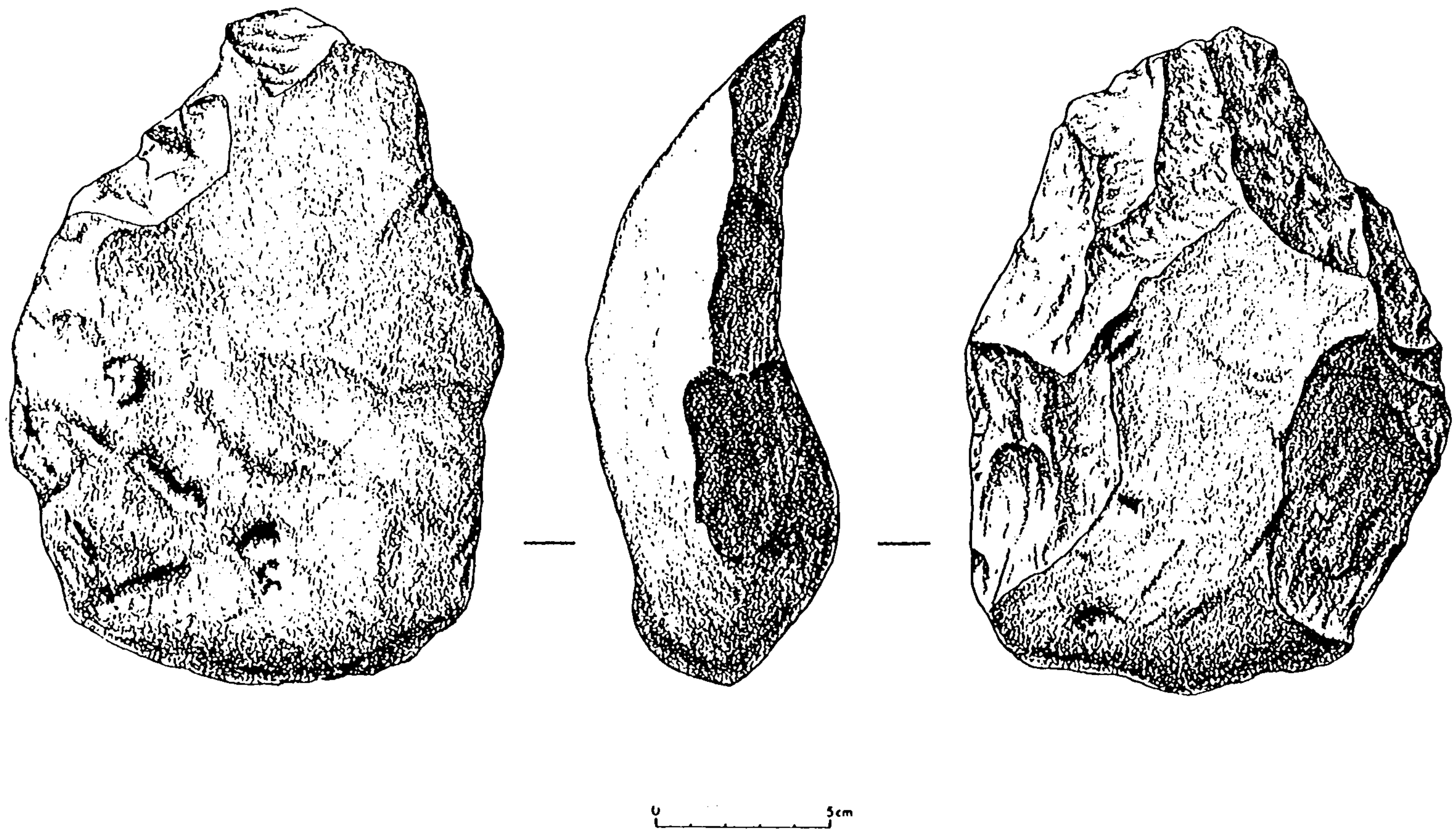


Fig. V 16. Tool of type C5 (Dafa 59) from Bose.

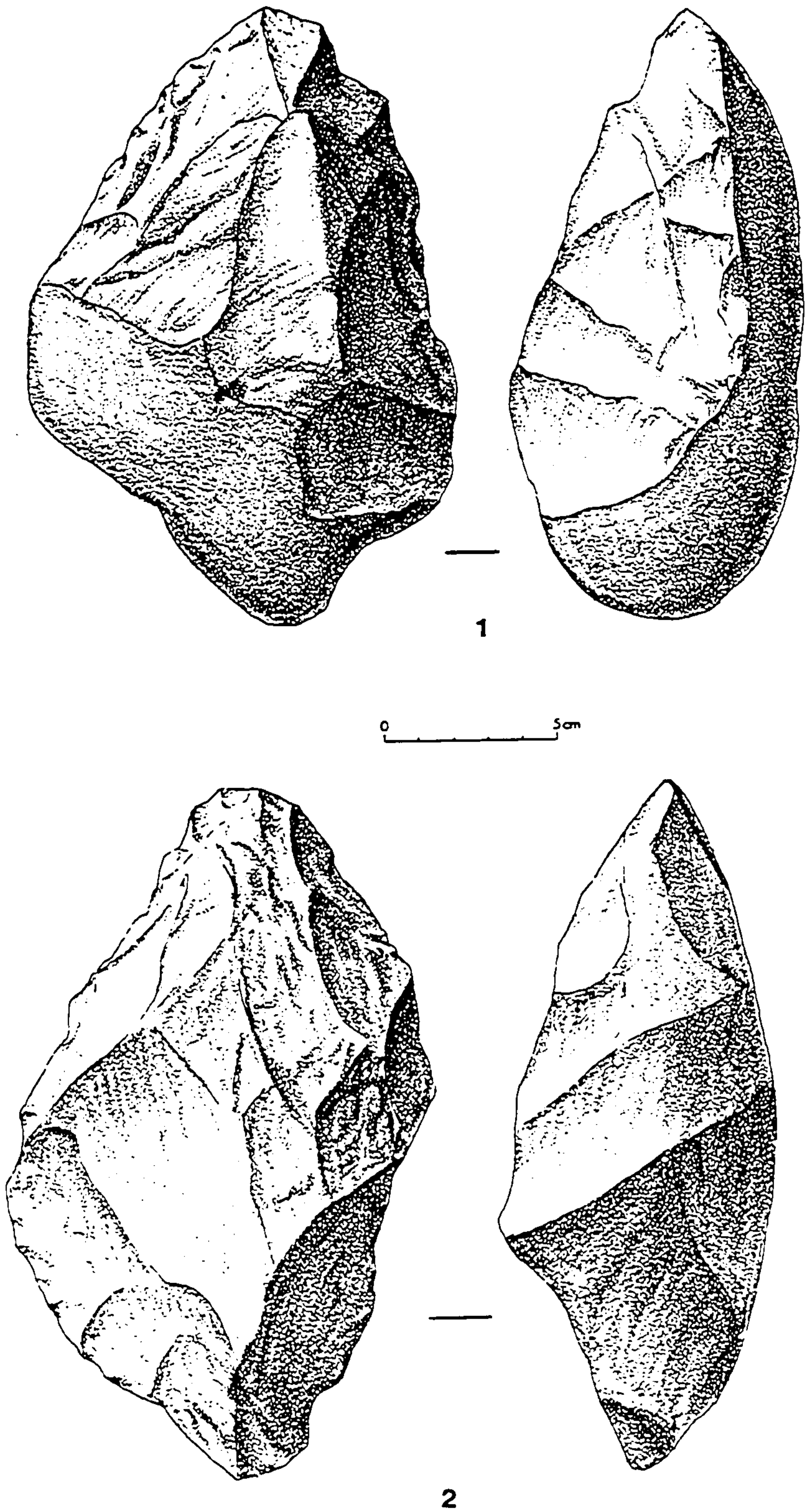


Fig. V 17. Tools of type C5 (1. Chaimu 4) and C7 (2. Dongzen 2) from Bose.

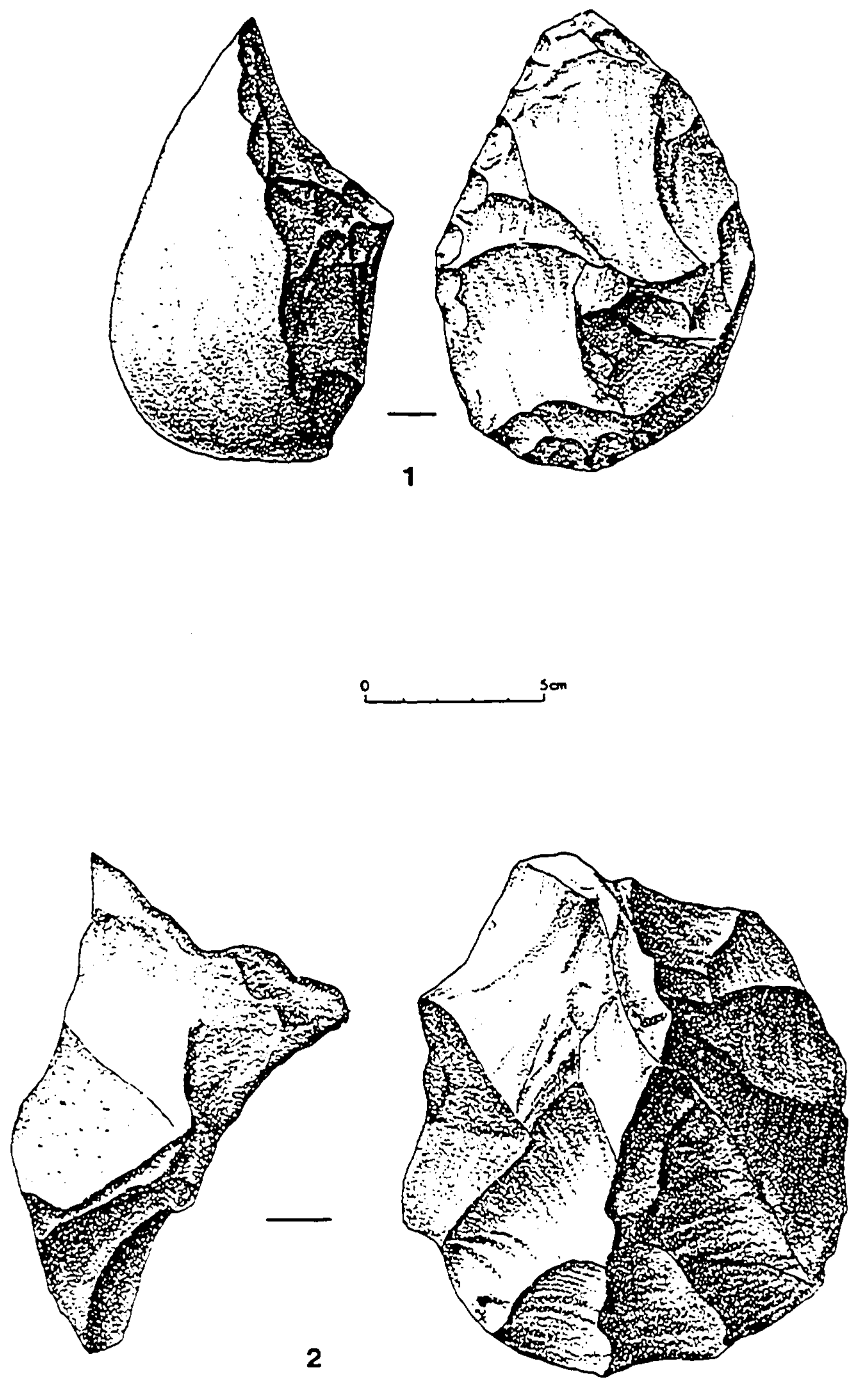


Fig. V 18. Tools of type C7 (1. Dongzen 5 2. Tanhe 3) from Bose.

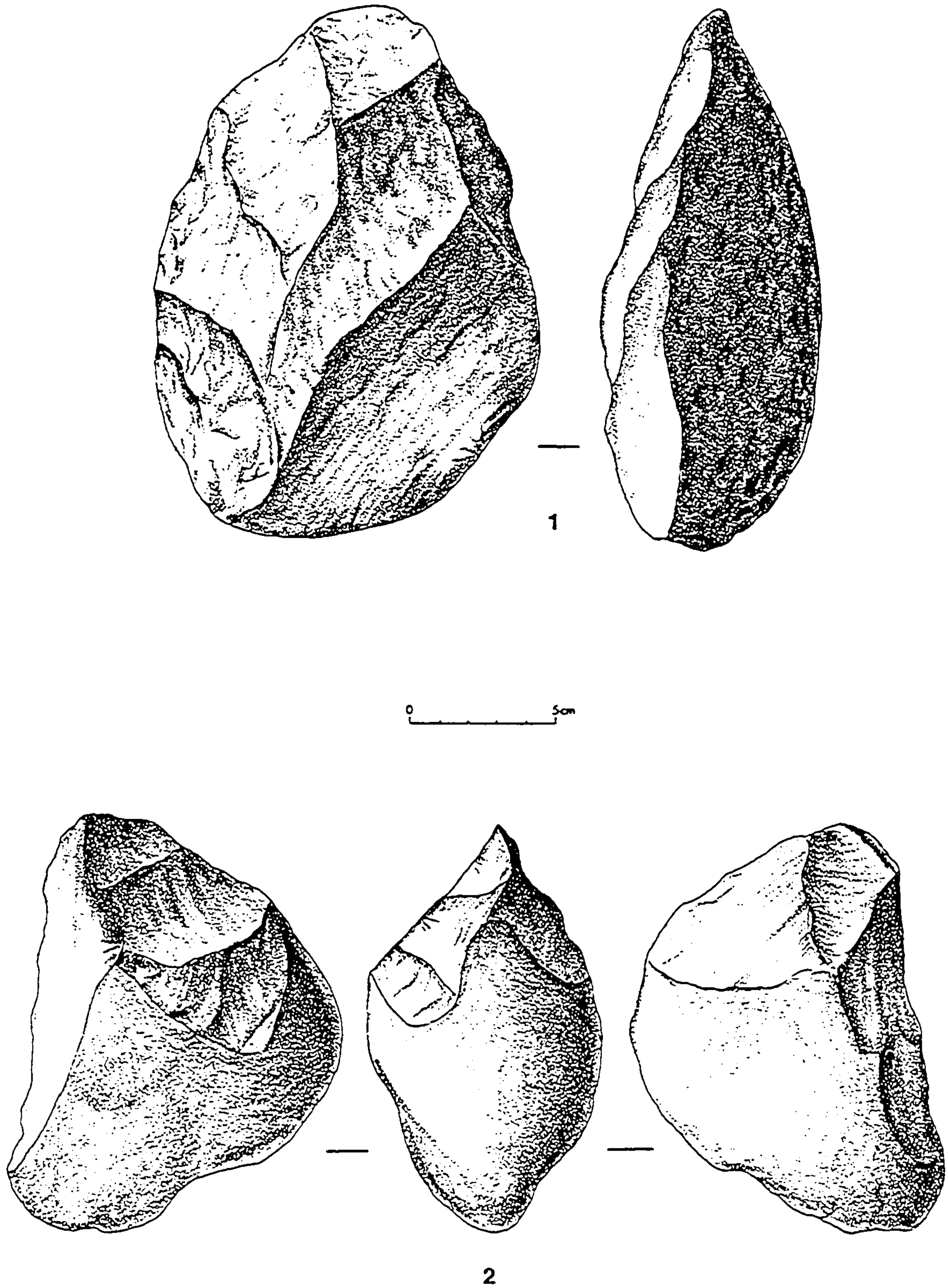


Fig. V 19. Tools of type C7 (1. Dongzen 6) and C10 (2. Nazhao 03) from Bose.

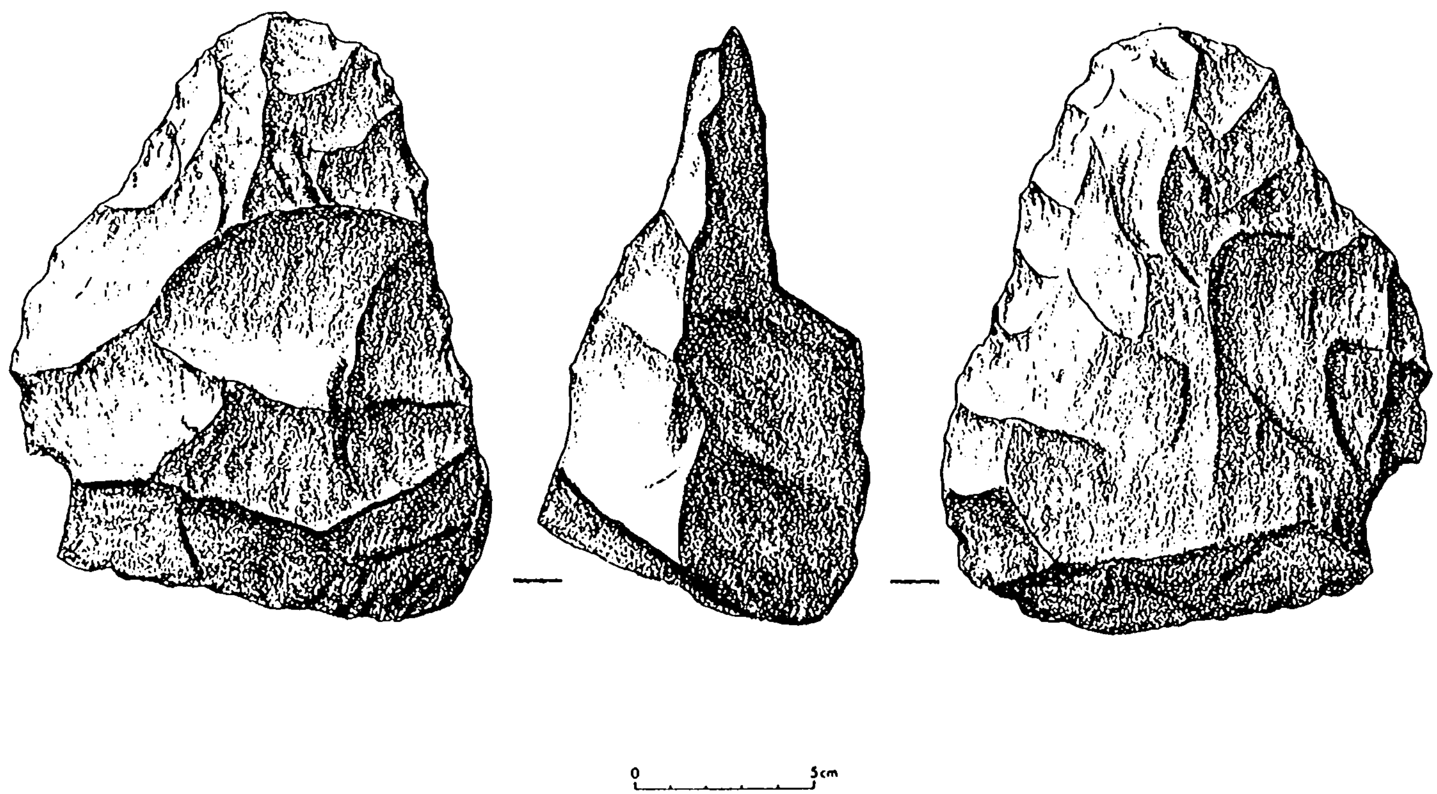


Fig. V 20. Tool of type C13 (Tanhe 4) from Bose.

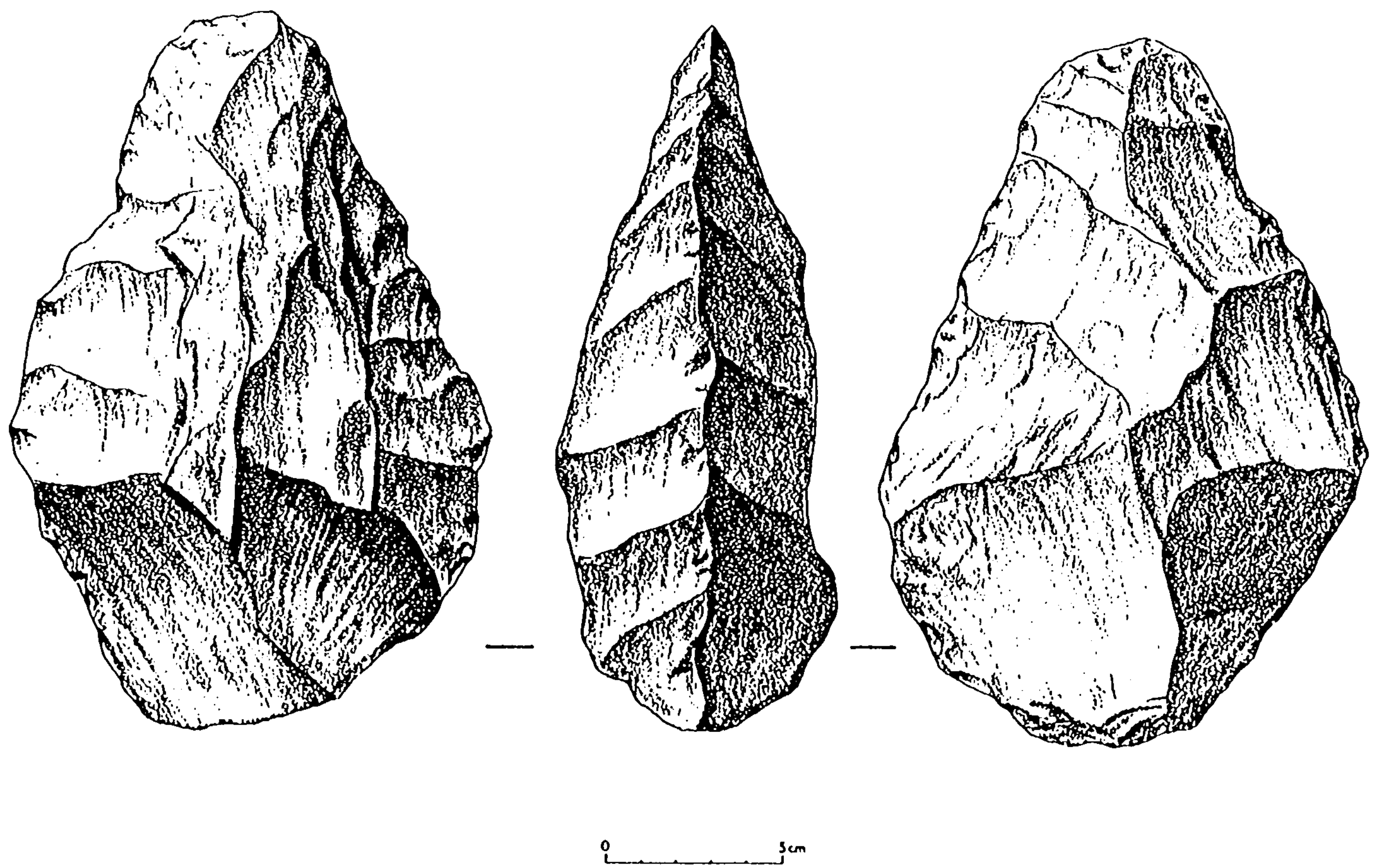


Fig. V 21. Tool of type C13 (Yangwucun 007) from Bose.

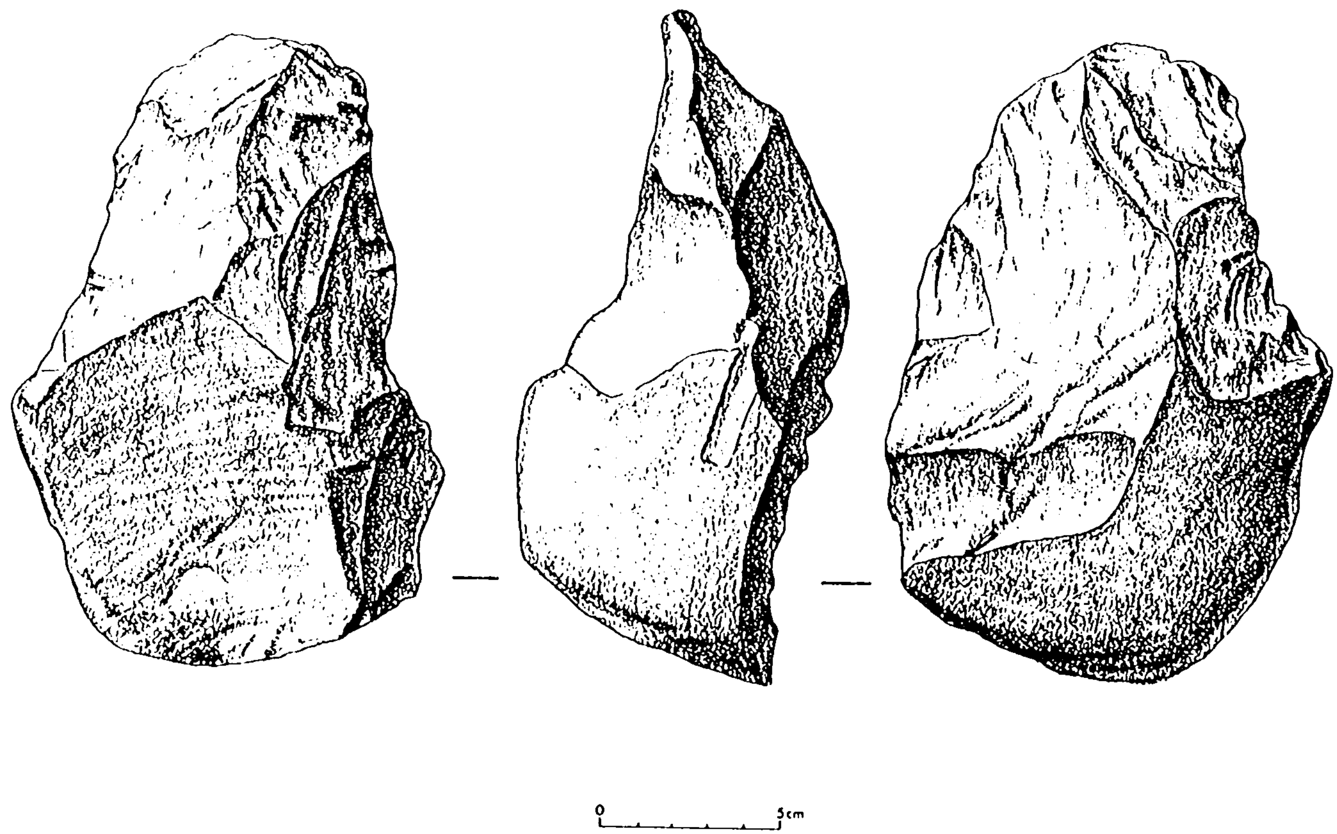


Fig. V 22. Tool of type C13 (Datong 013) from Bose.

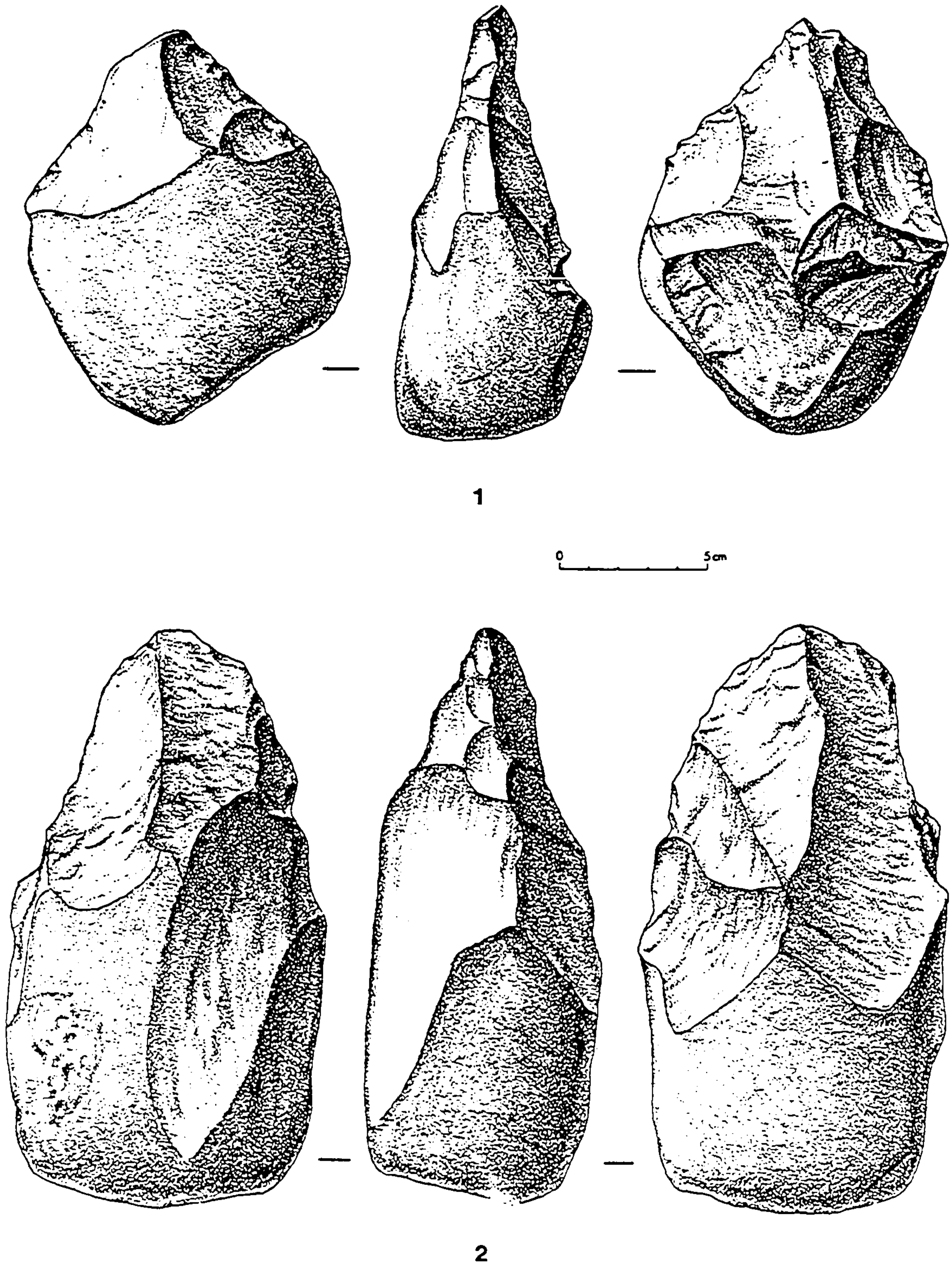


Fig. V 23. Tools of type C13 (1. Bose 10 2. Yangwucun 018) from Bose.

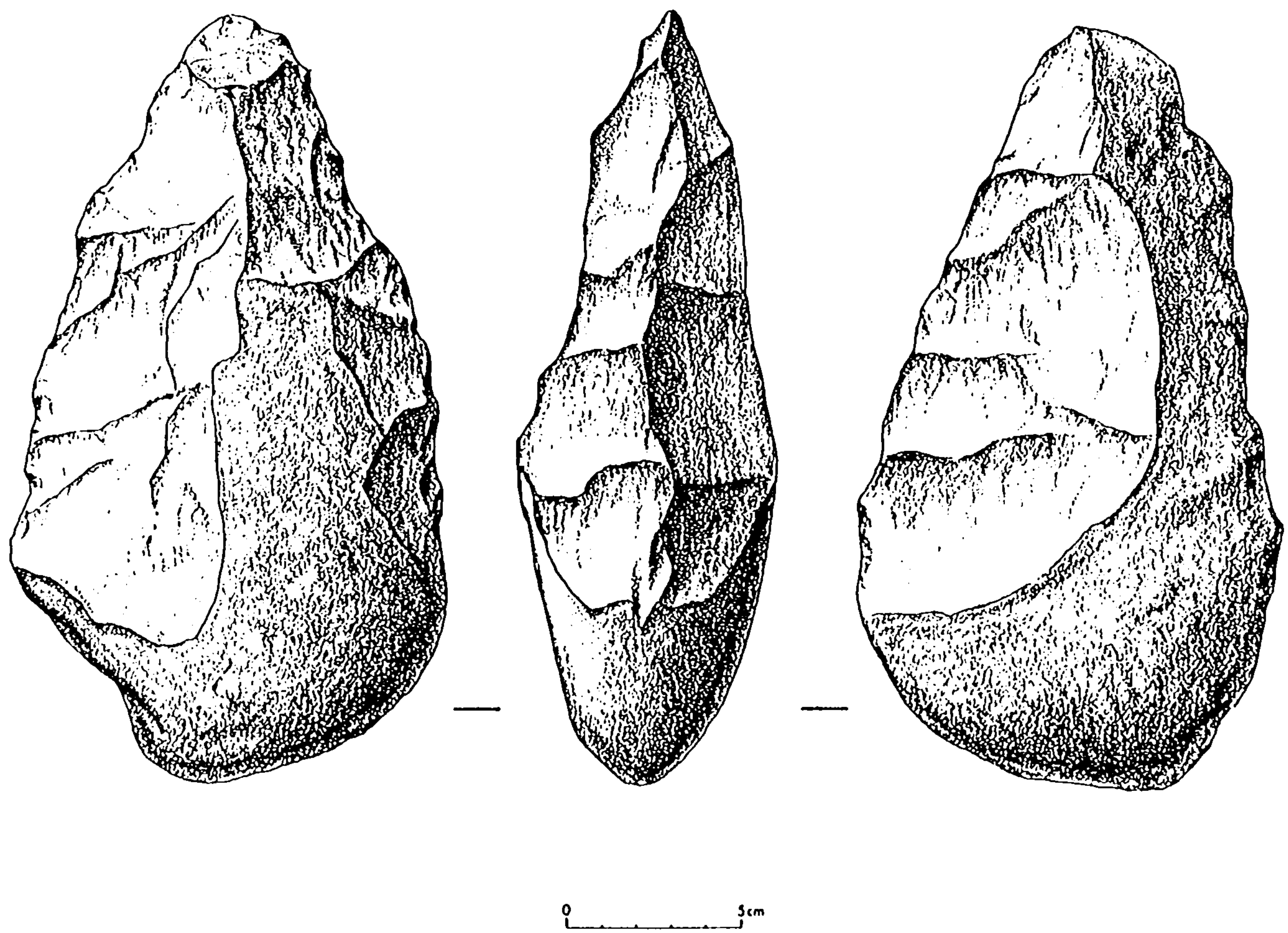


Fig. V 24. Tool of type C13 (Baigu 005) from Bose.

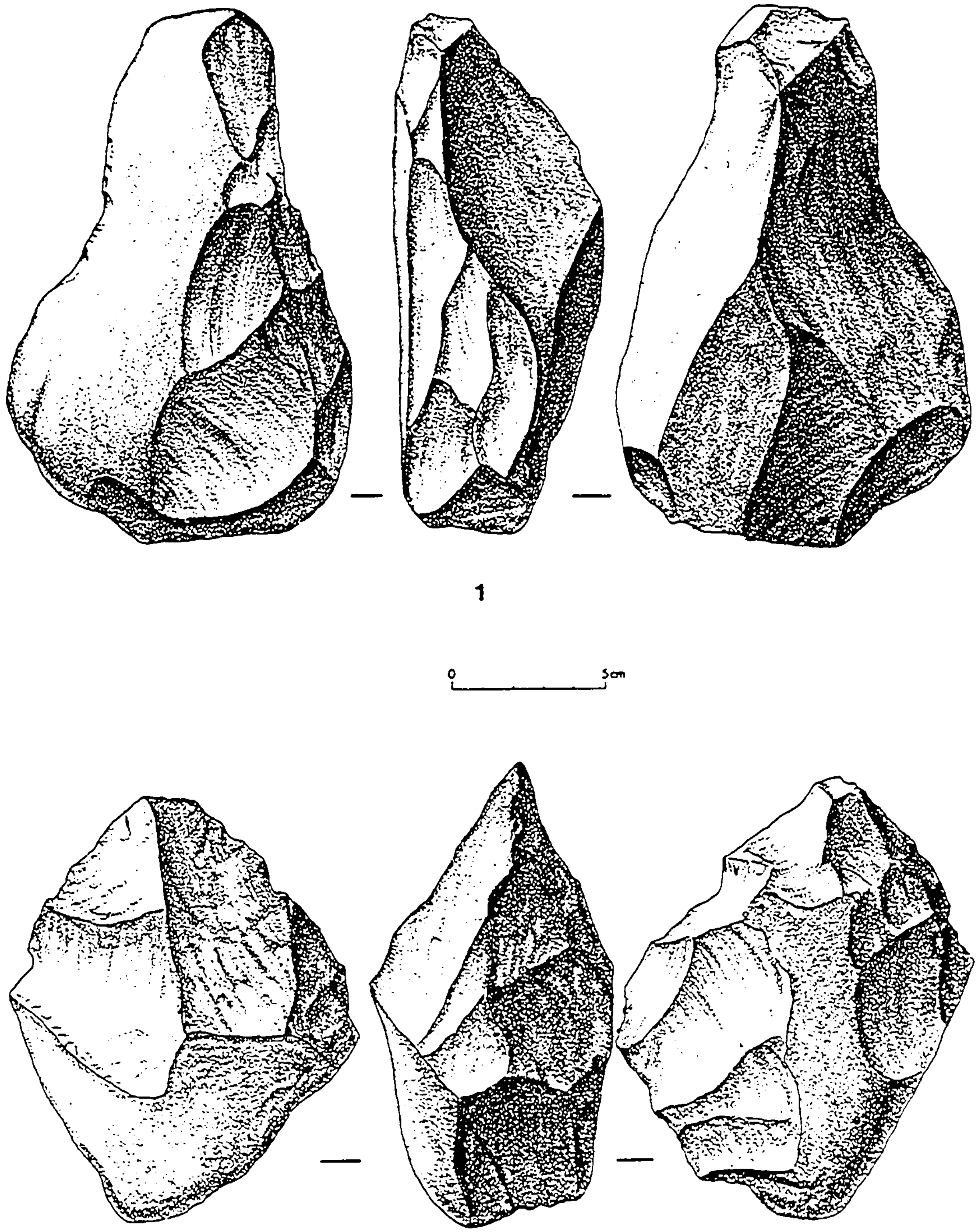


Fig. V 25. Tools of type C13 (1. Damei 143 2. Dongzen 05) from Bose.

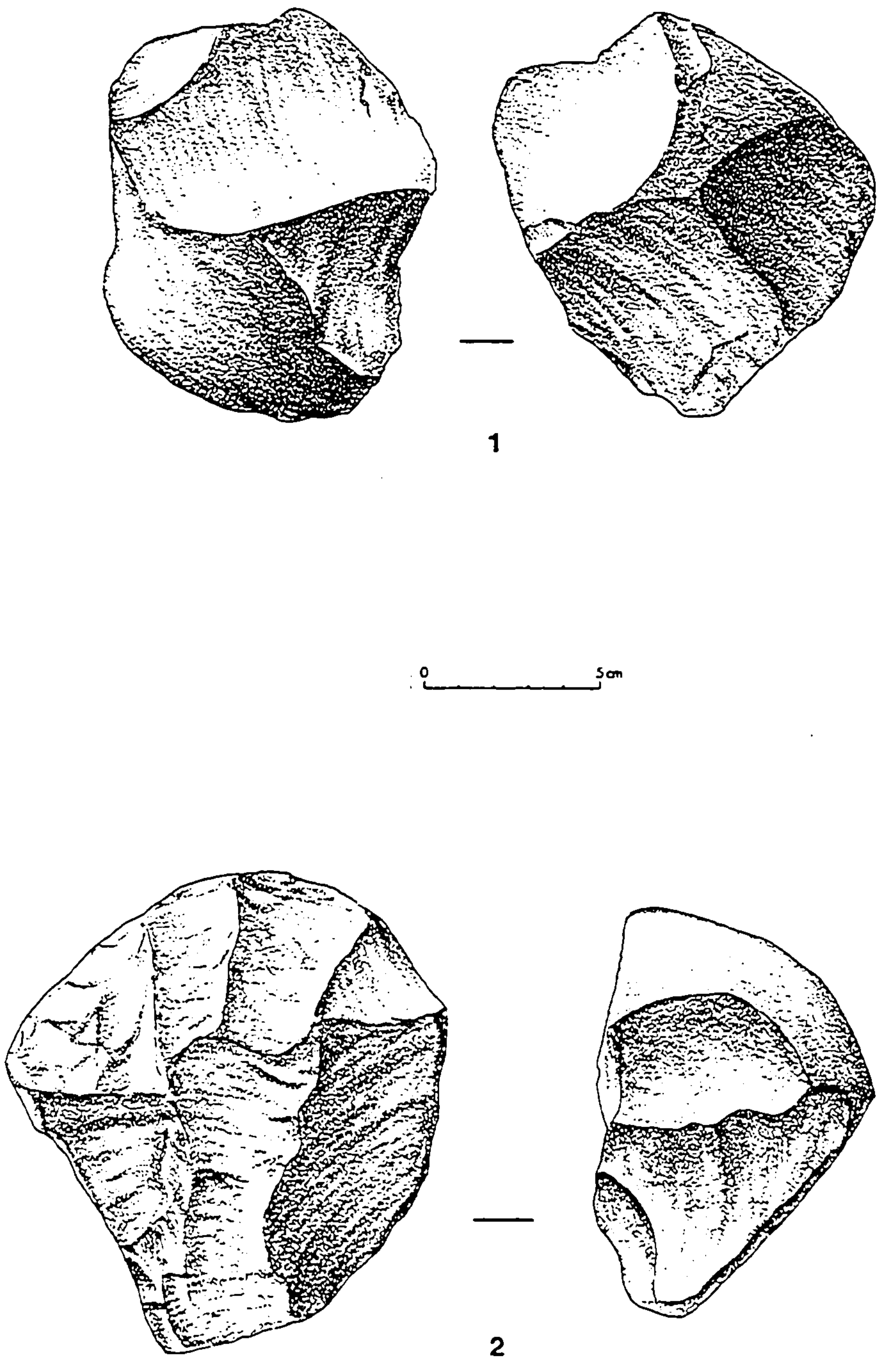


Fig. V 26. Tools of type C17 (1. Tanhe 11) and C16 (2. Tanhe 6) from Bose.

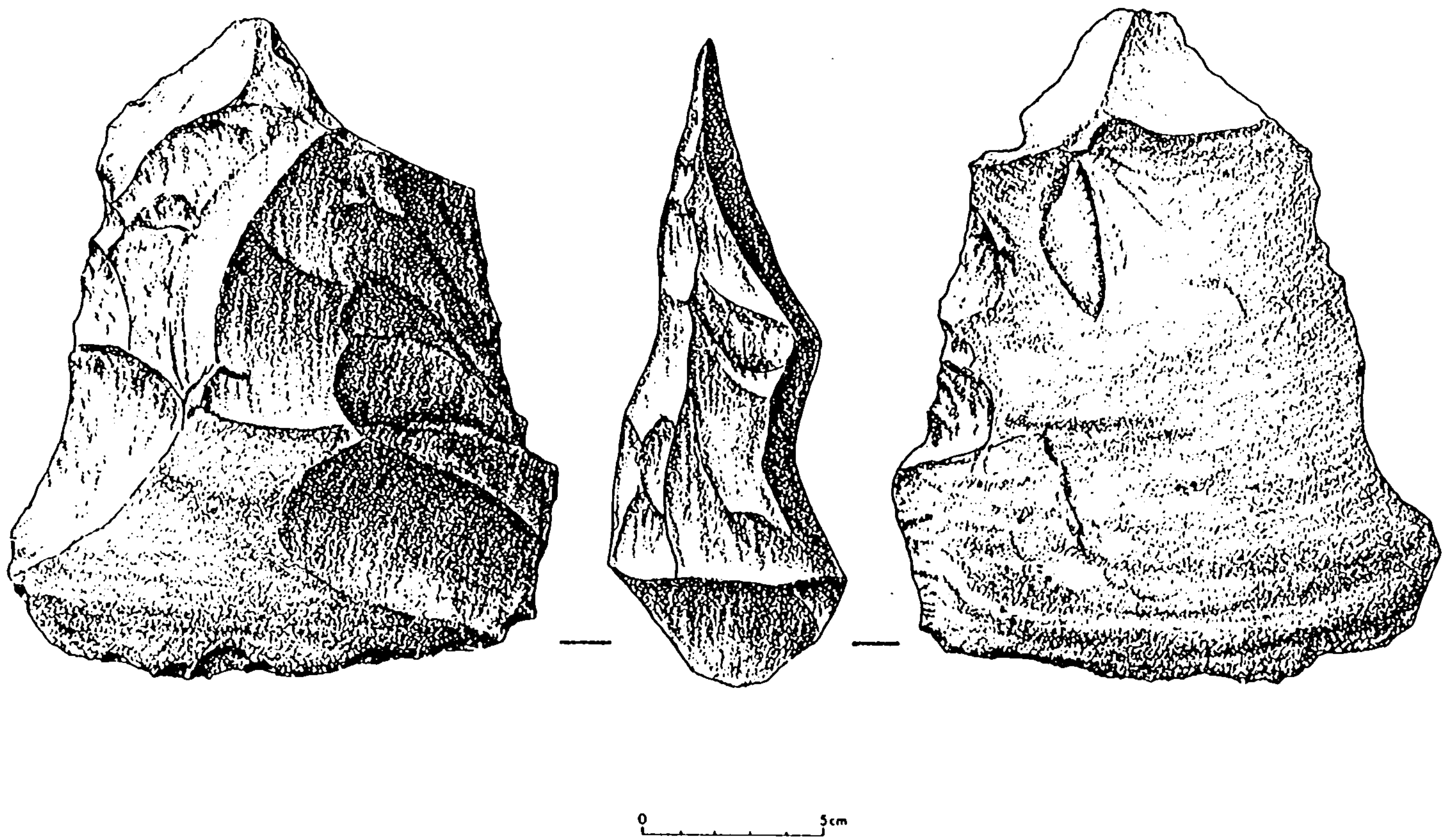


Fig. V 27. Tool of type F2 (Baigu 53) from Bose.

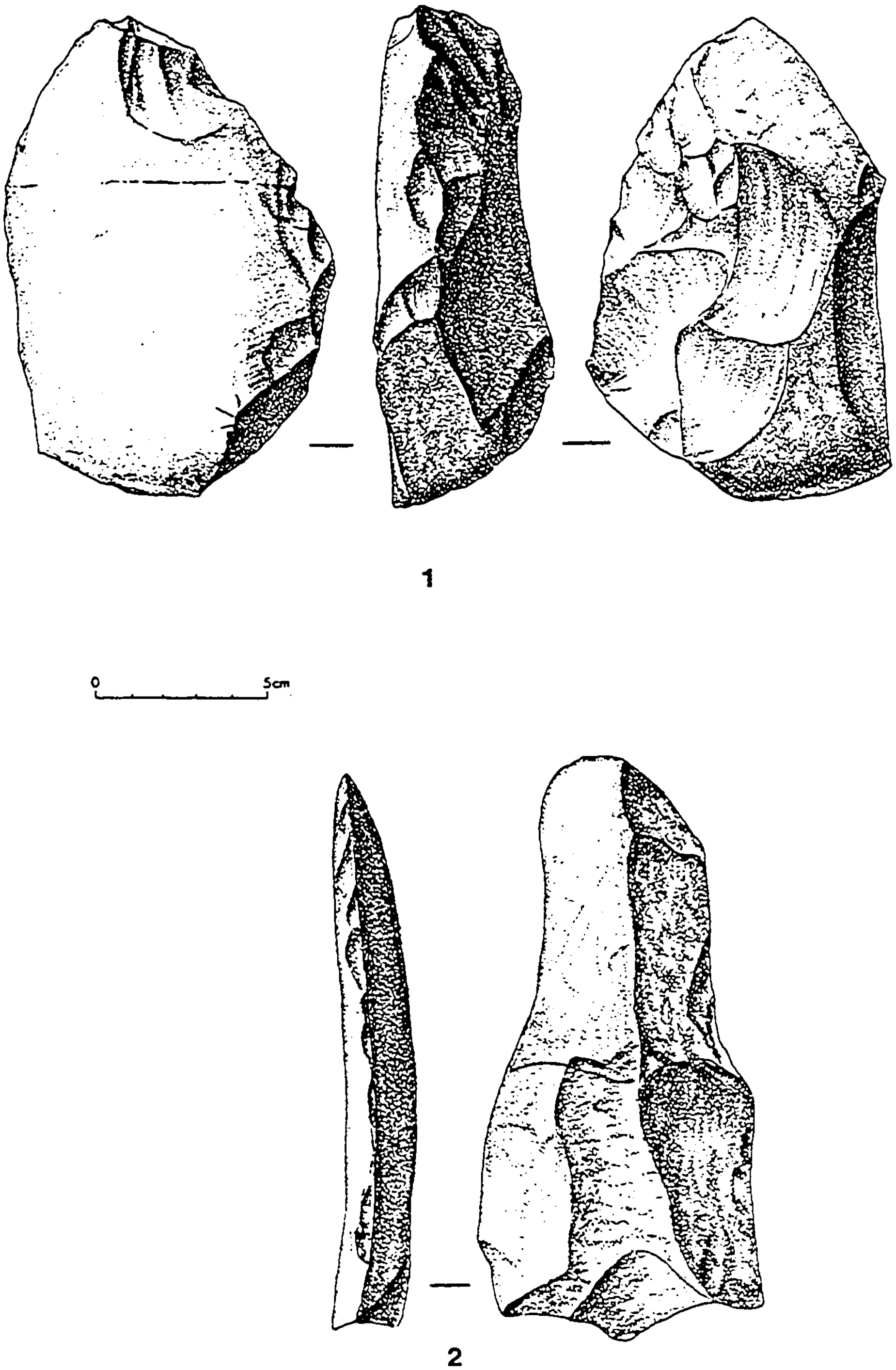


Fig. V 28. Tools of type F12 (1. Nanposhan 1) and F5
(2. Dongzen 1) from Bose.

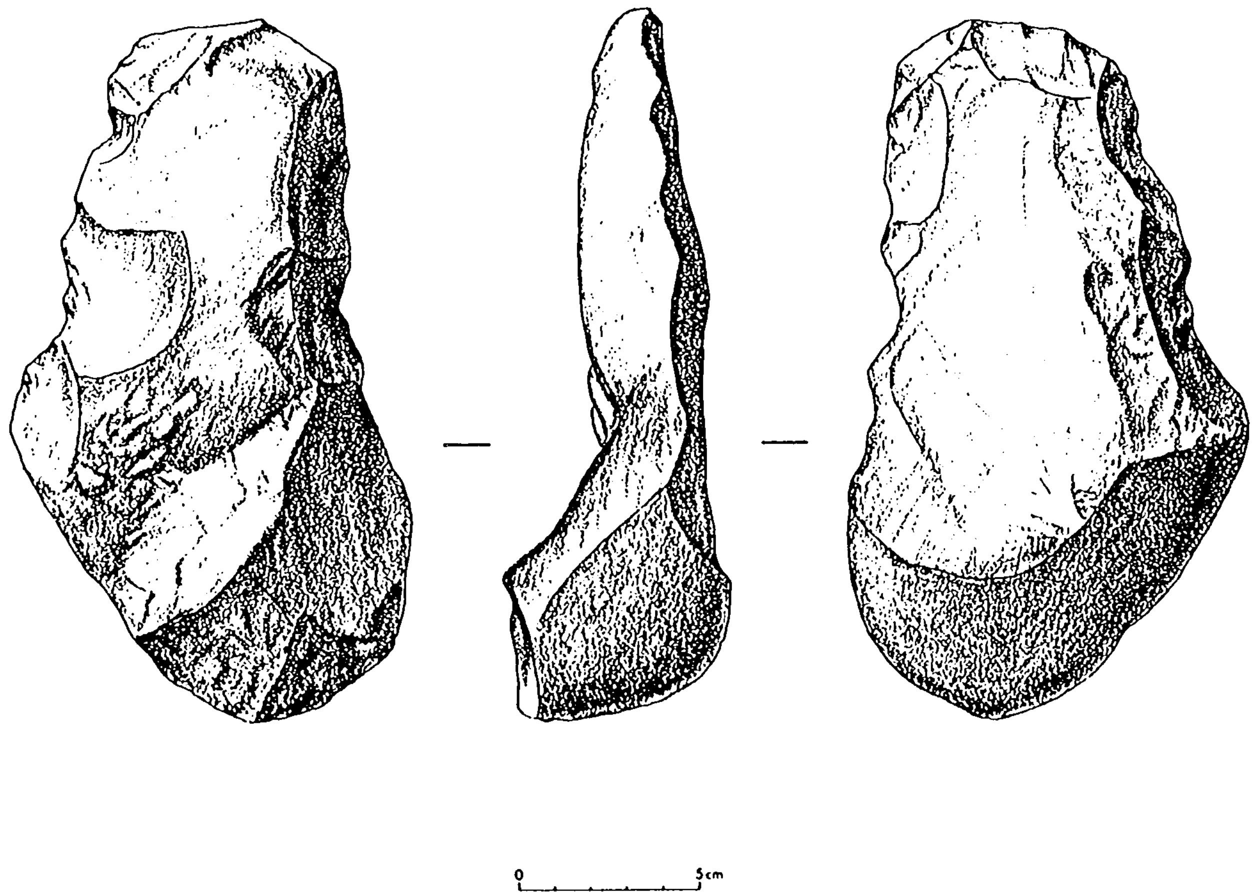


Fig. V 29. Tool of type F16 (Chaimu 1) from Bose.

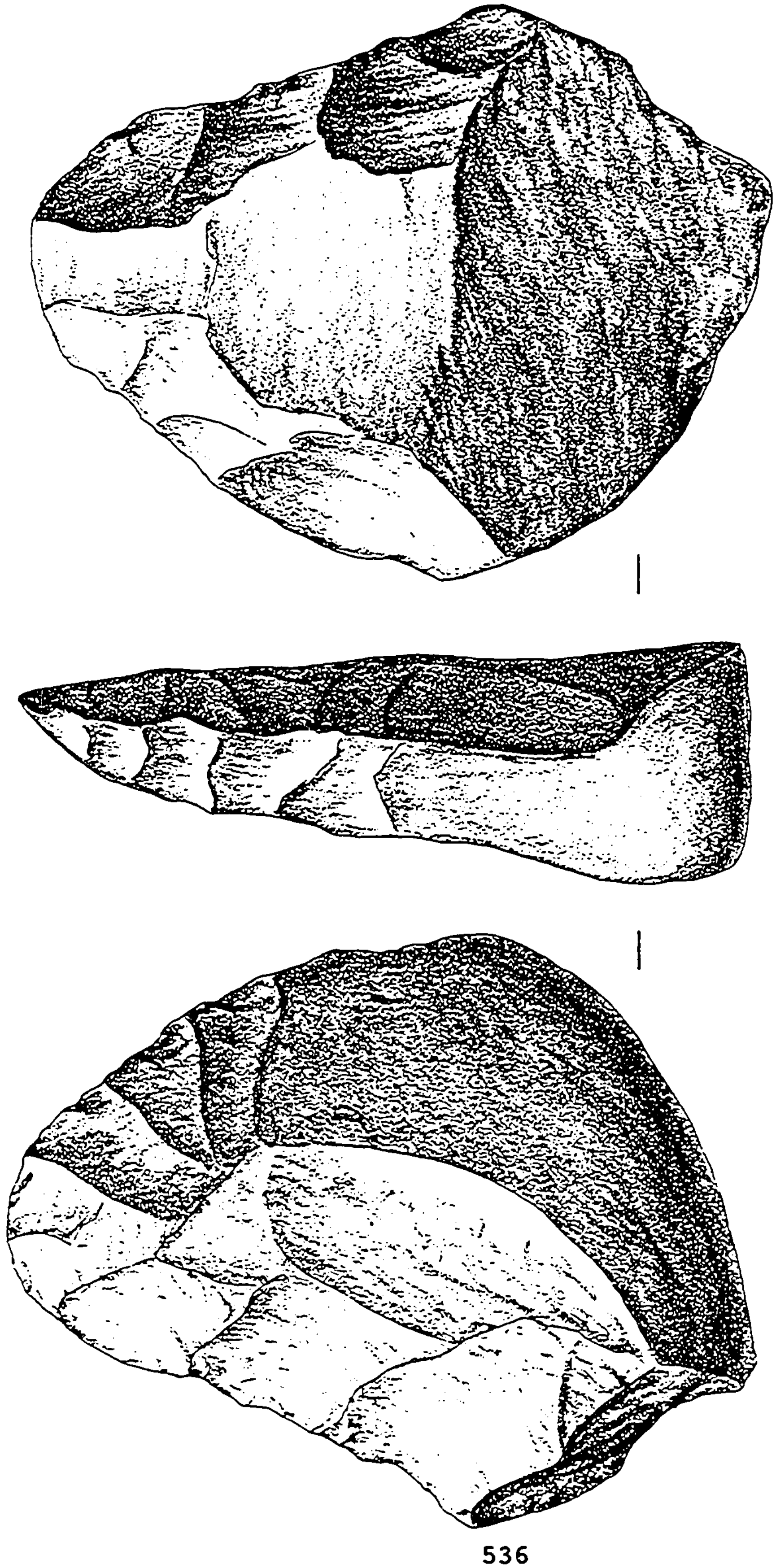


Fig. V 30. Tool of type F16 (Lioufen 02) from Bose.

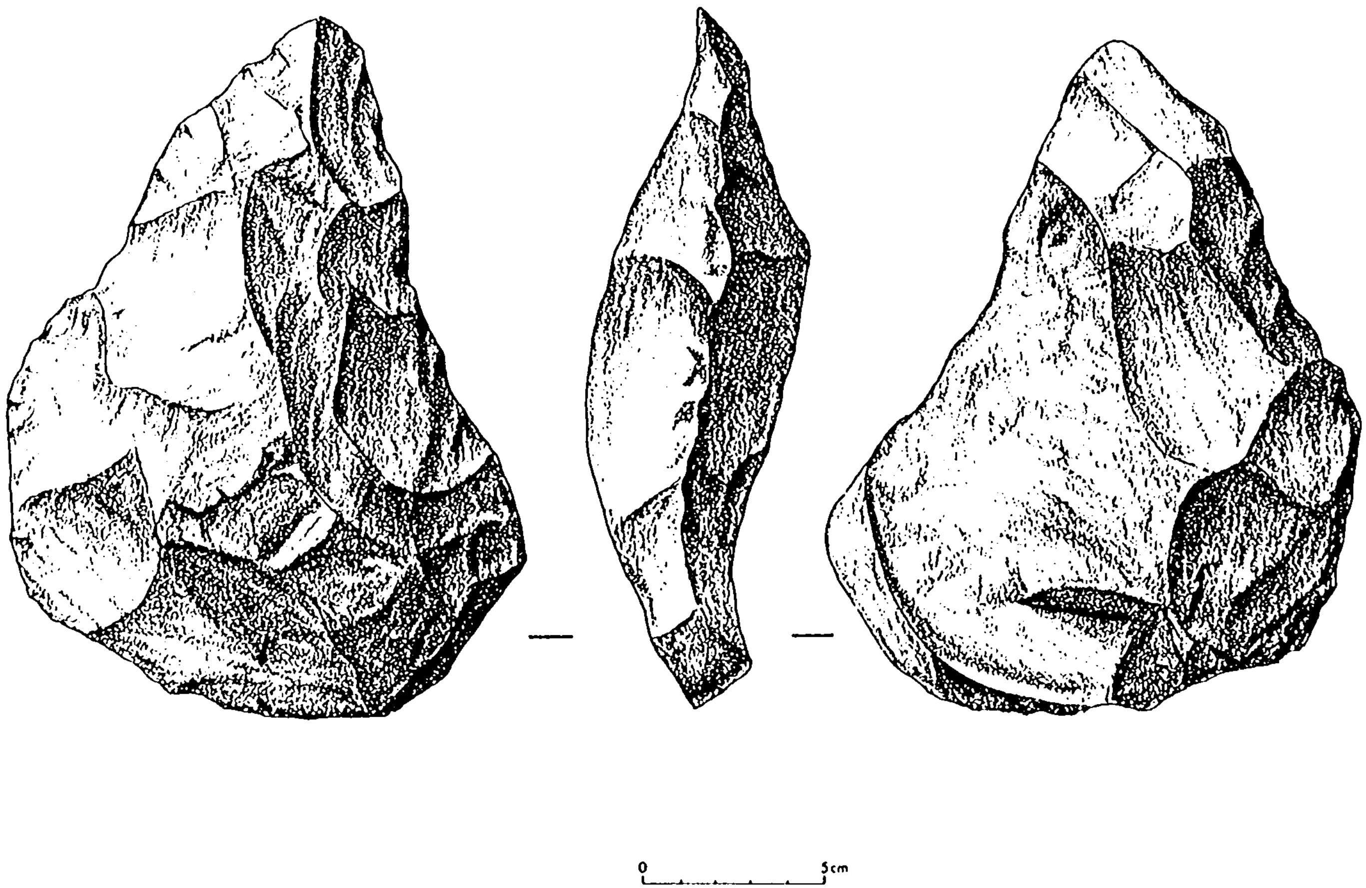


Fig. V 31. Tool of type F16 (Dongsun 03) from Bose.

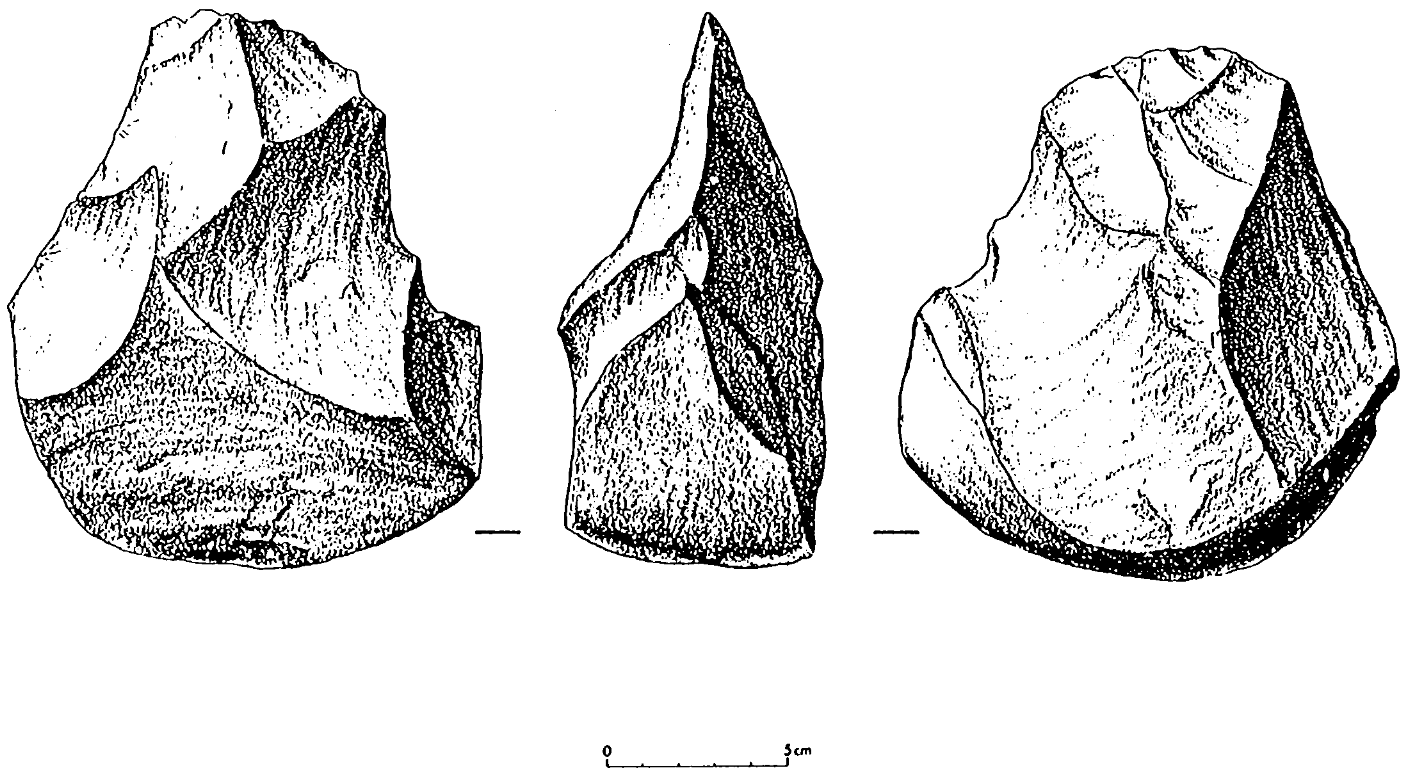


Fig. V 32. Tool of type F16 (Nazhao 01) from Bose.

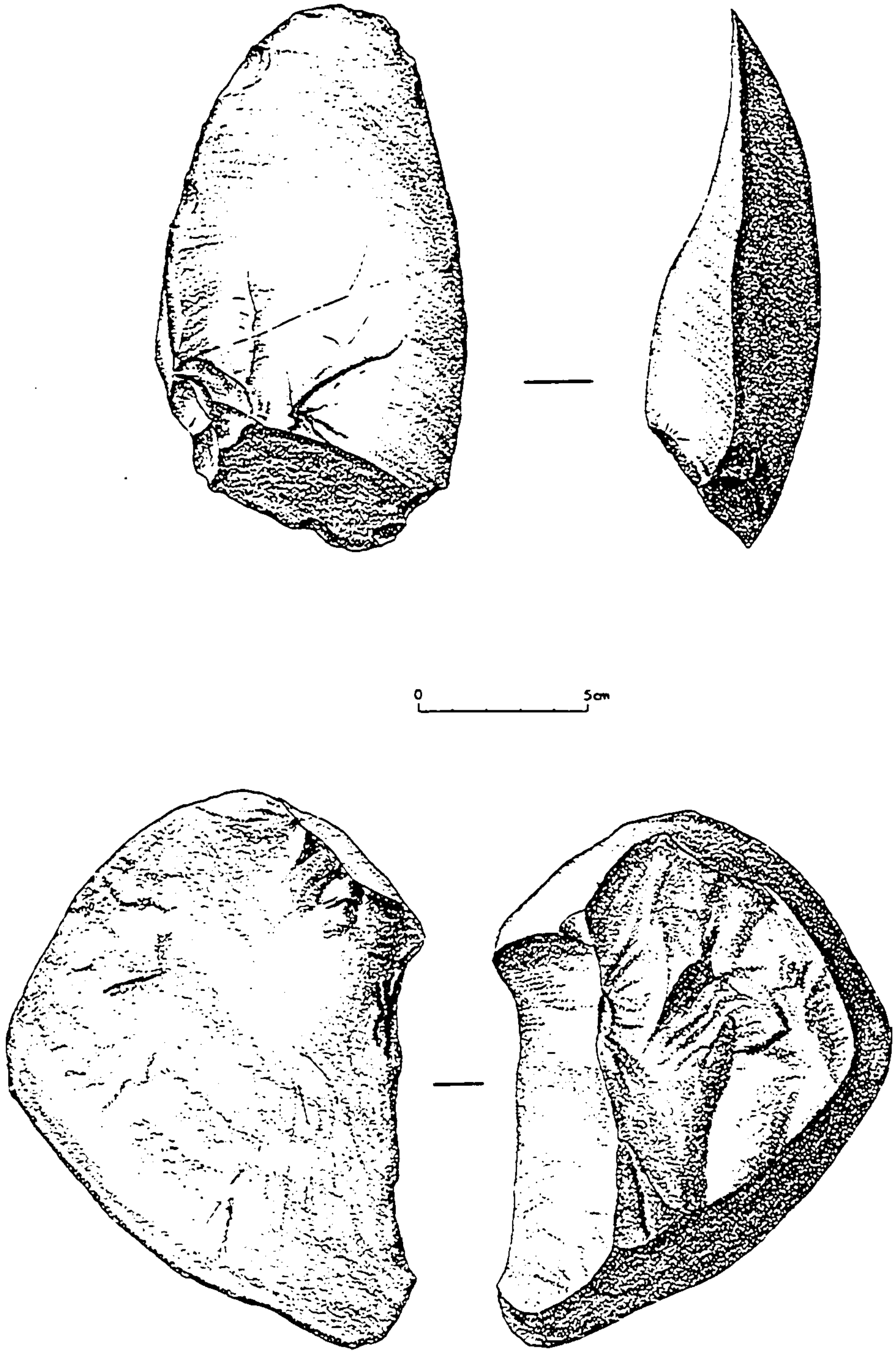


Fig. V 33. Tools of type U1 (1. Chaimu 2 2. Tanhe 2) from Bose.

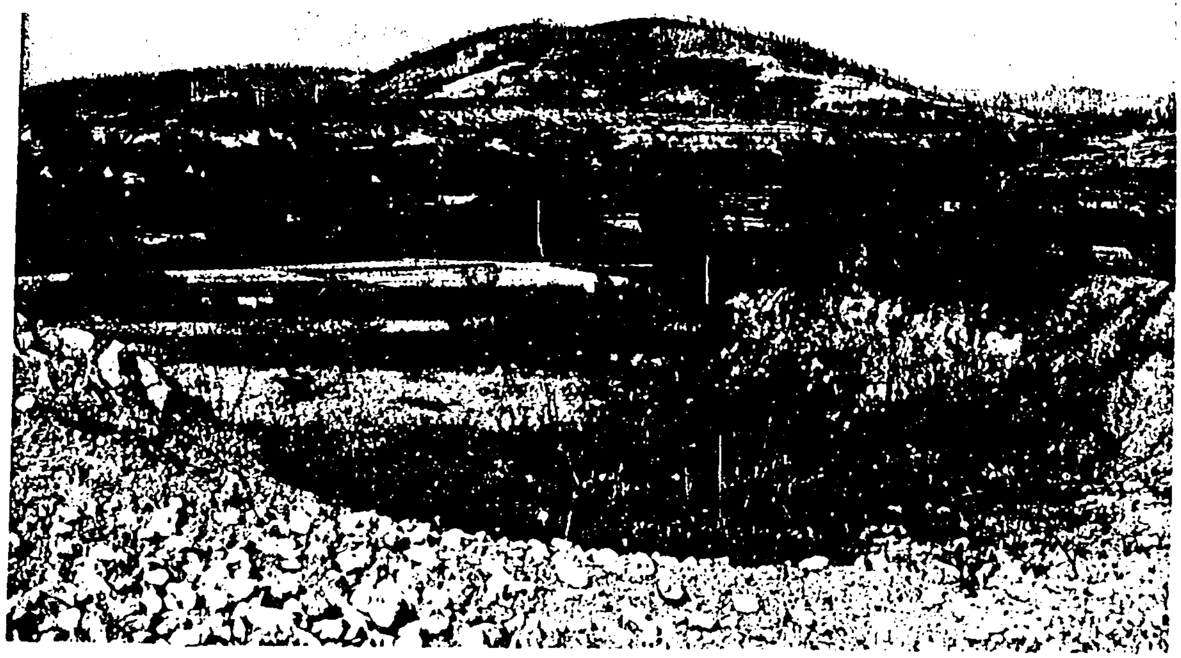


Fig. V 34. Cobbles which are found everywhere along the You River.

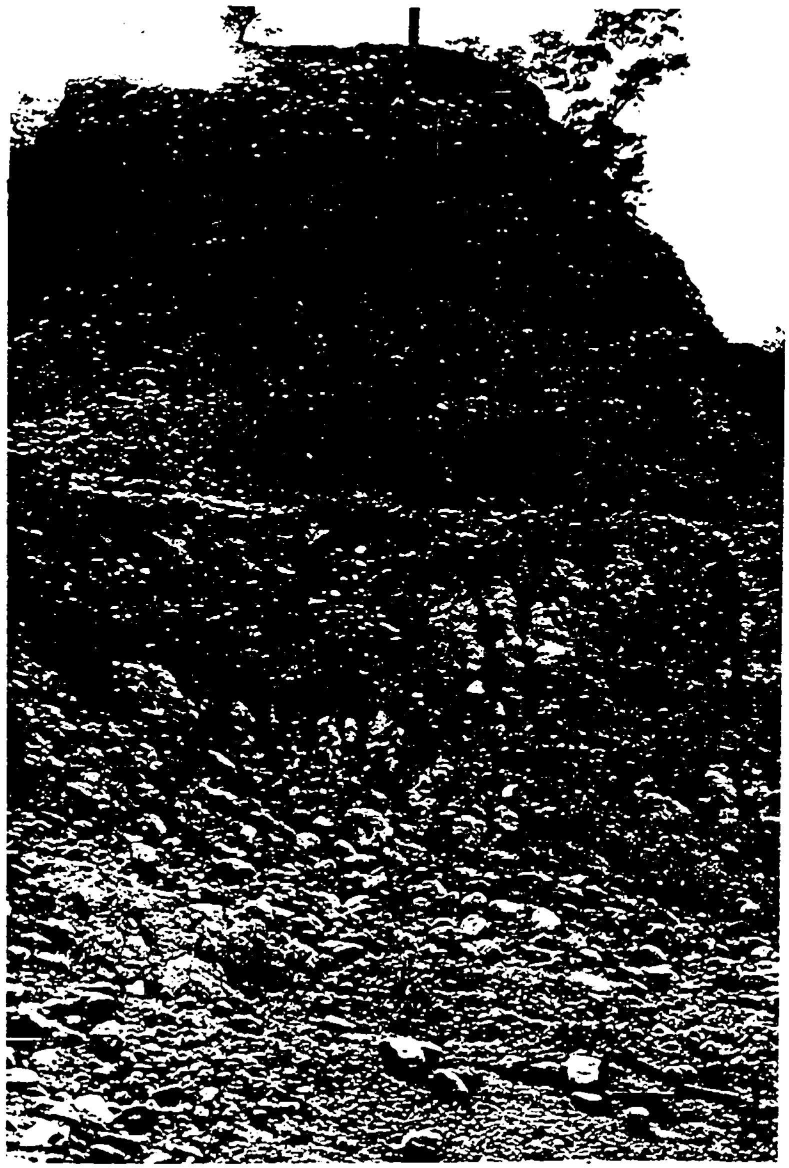


Fig. V 35. Exposed section near You River.



Fig. V 36. Surface artifacts on the second terrace next to Posuan village.

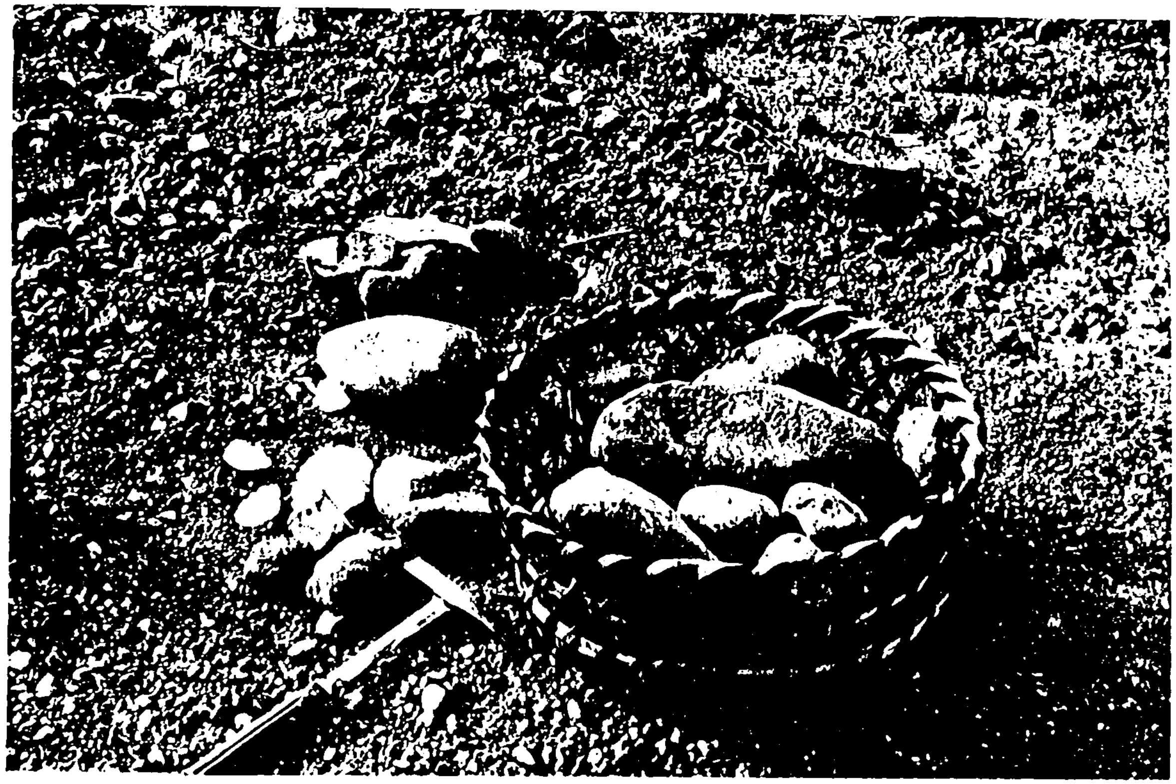


Fig. V 37. Collected cobbles from Nanposhan at Bose.



Fig. V 38. Cobbles used in the replicative studies, Bose.

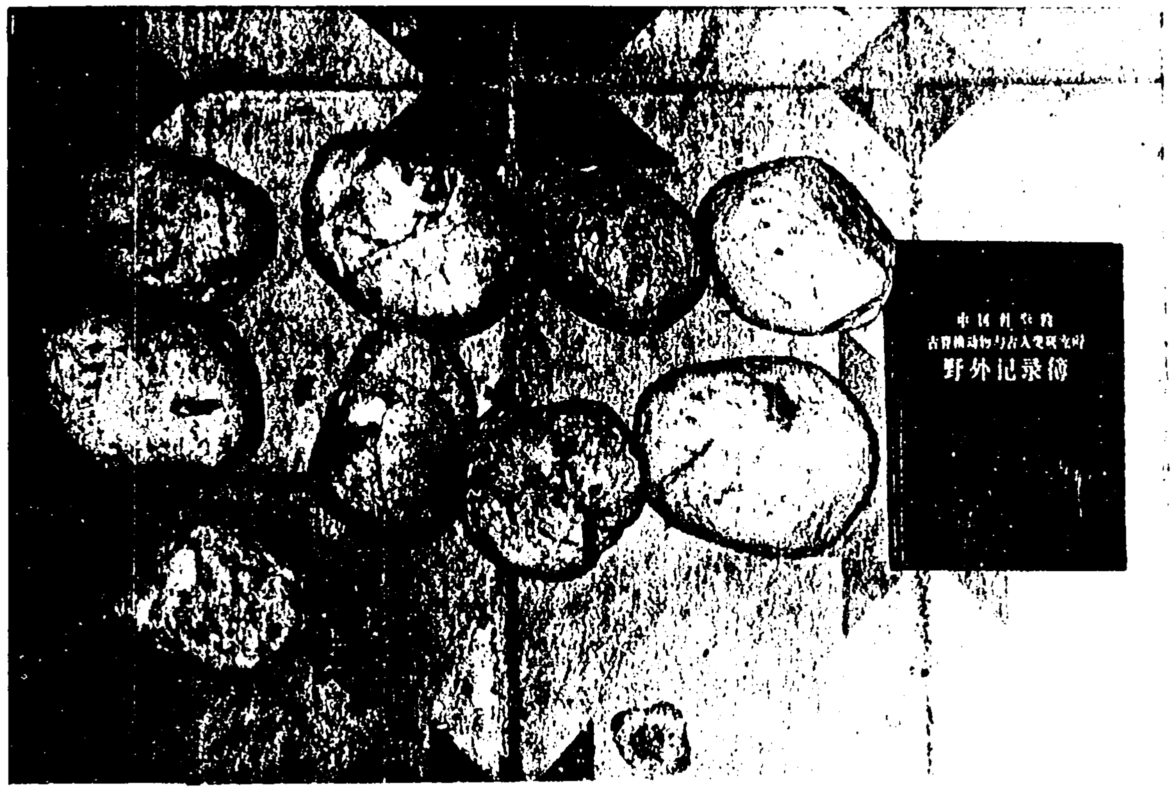


Fig. V 39. Hammerstones used in the replicative studies, Bose.

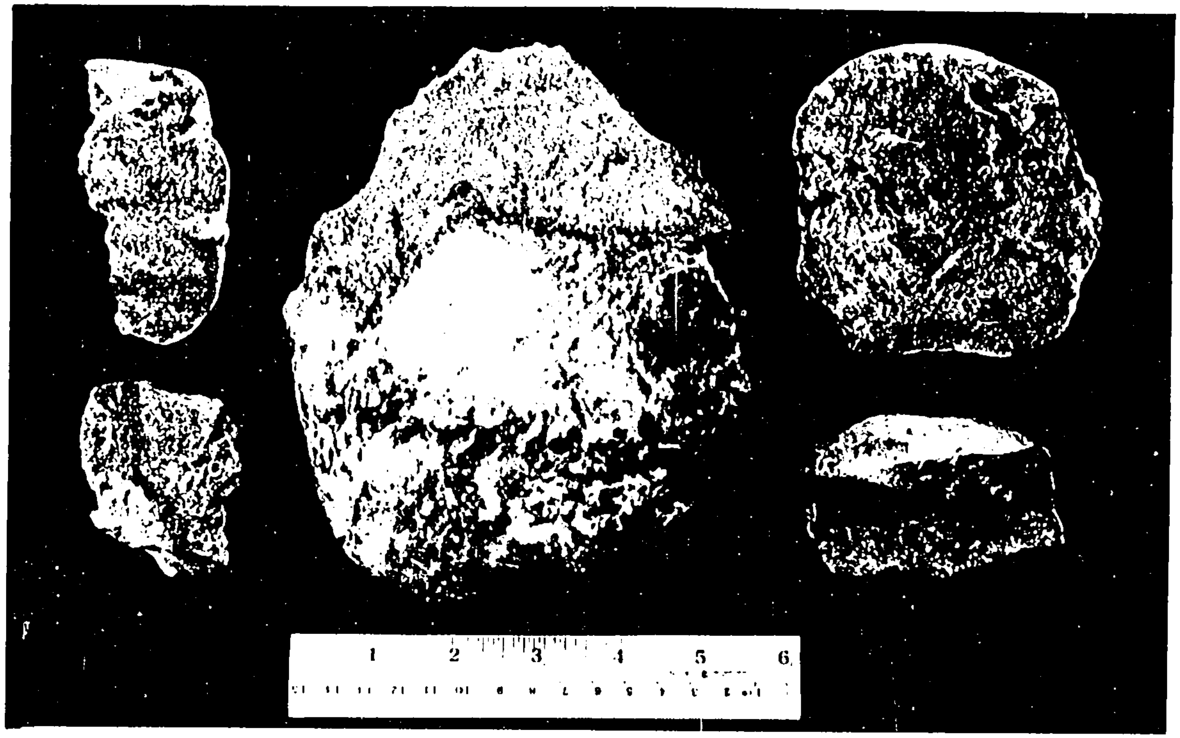


Fig. V 40. Replication: C5, of Bose produced by block on block technique.



Fig. V 41. Replication: C5, of Bose produced by hard hammer direct percussion technique.

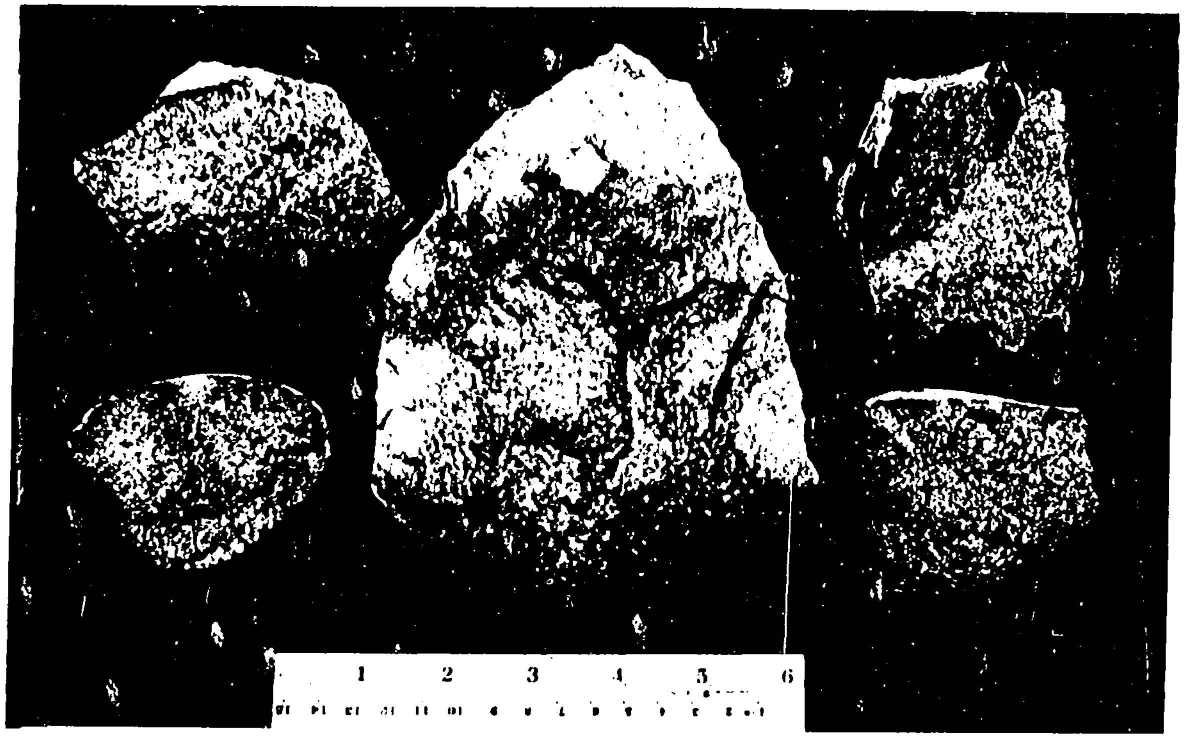


Fig. V 42. Replication: C13, of Bose. The tool still retains a large butt with cortex.

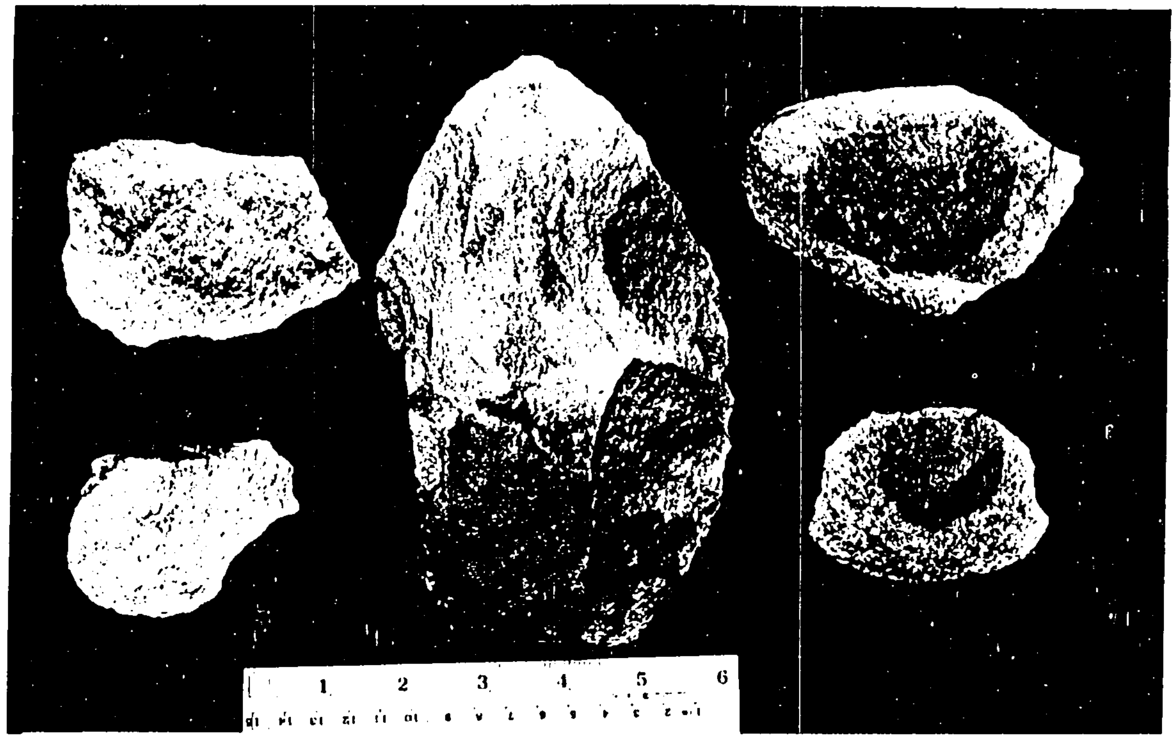


Fig. V 43. Replication: C13, of Bose. The tool has both lateral edges extending to the end of the butt.

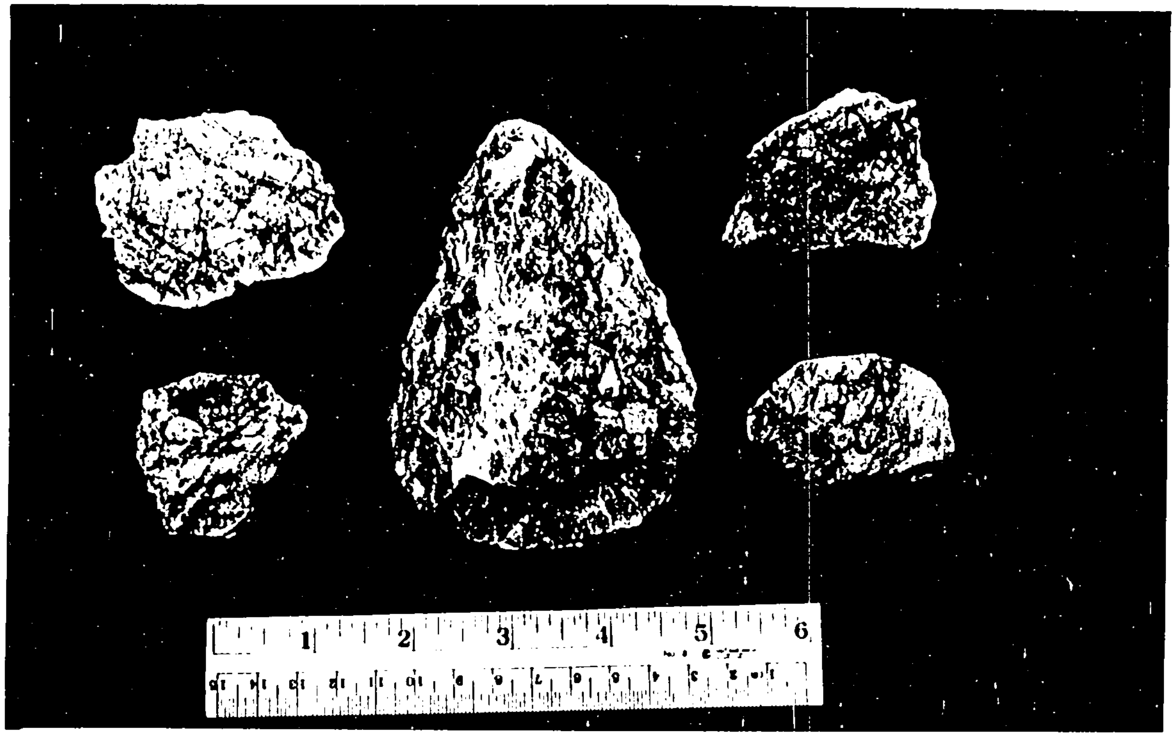


Fig. V 44. Replication: C13, of Bose. The entire circumference is trimmed bifacially.

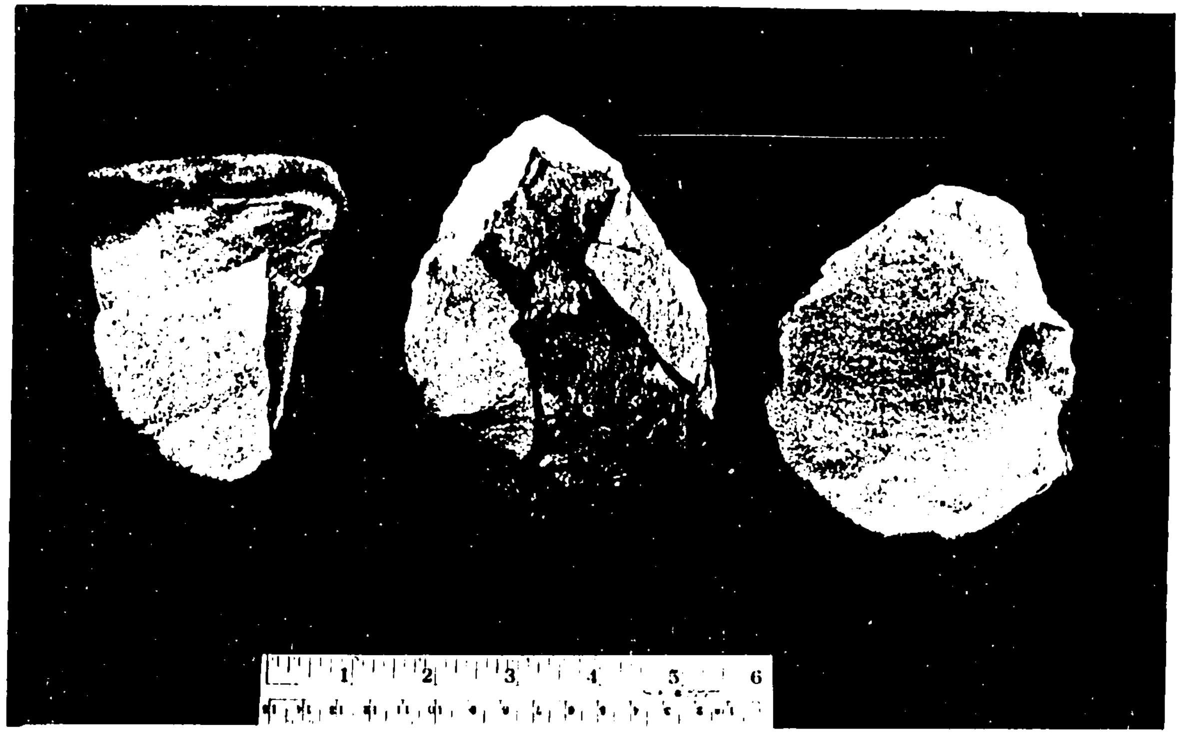


Fig. V 45. Replication: Large flakes with final tool (middle), Bose.

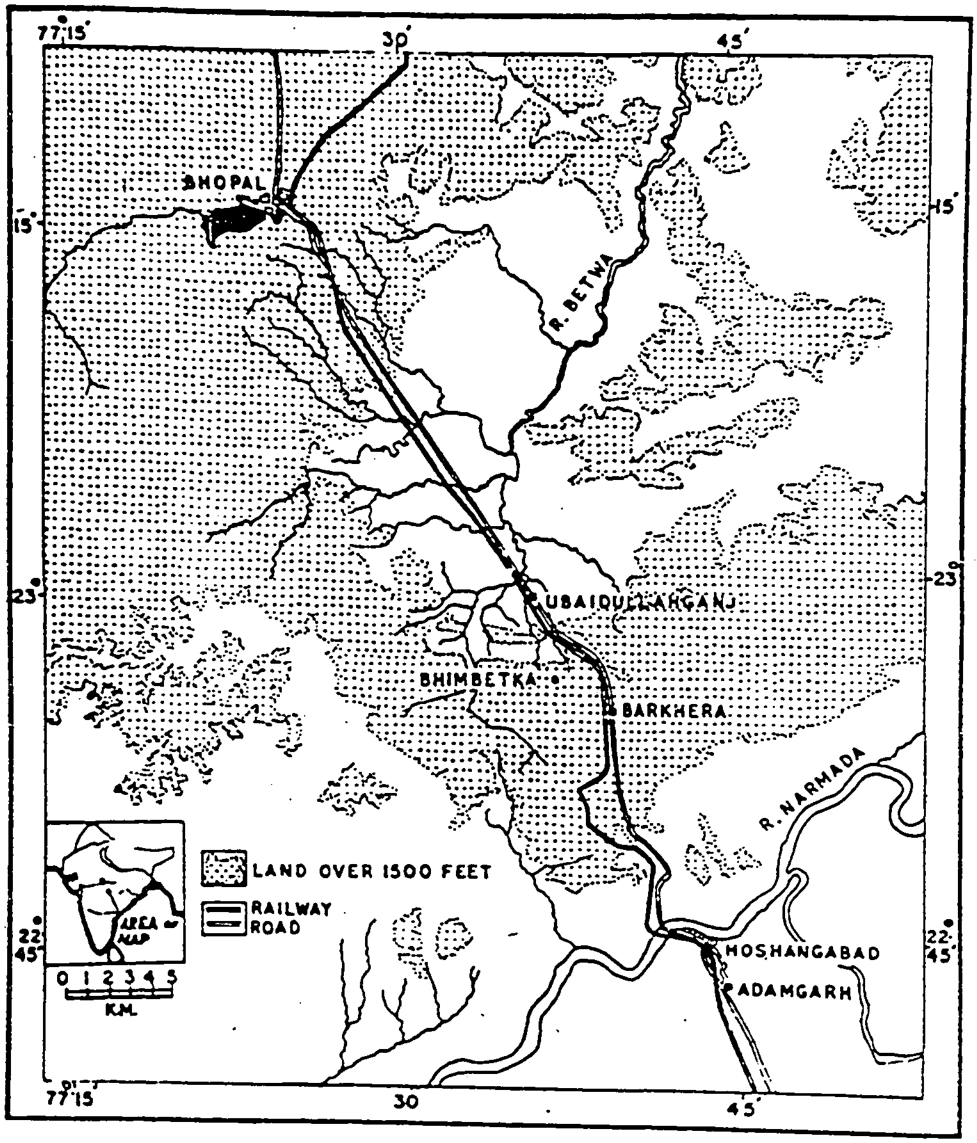


Fig. VI 1. Map of Bhimbetka region (Mishra, 1978: Fig. 1).





Fig. VI 2. Rock-shelter and cave of Bhimbetka.

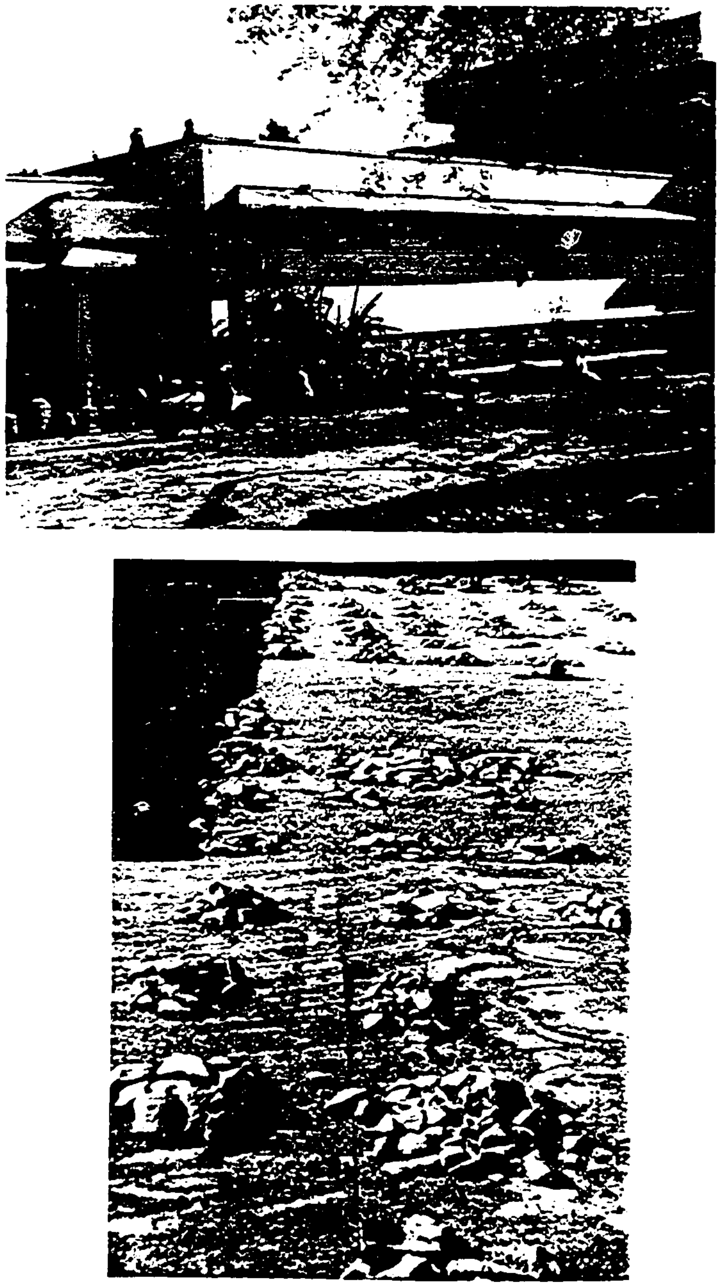
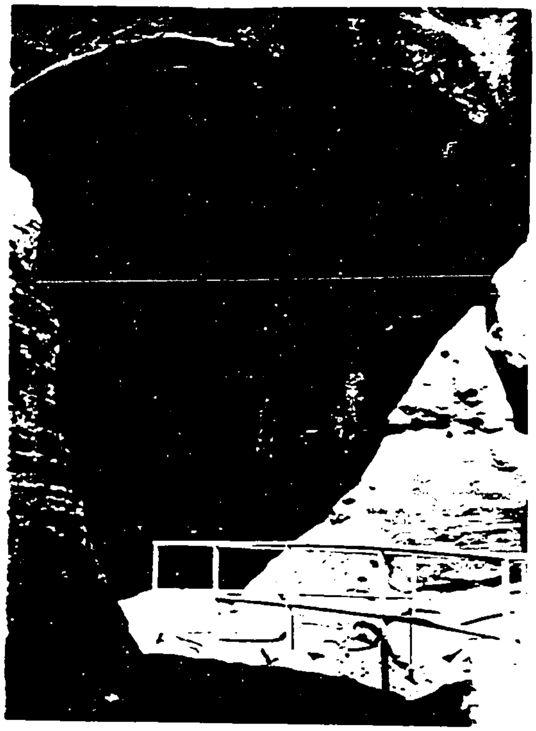


Fig. VI 3. The museum of Vikram University and Dr. V. C. Wakankar's materials were stored on the roof of the museum.





Fig. VI 4. Tourist trails between the rock shelters of Bhimbetka (above), a view from Bhimbetka hill to the Narmada valley (below).



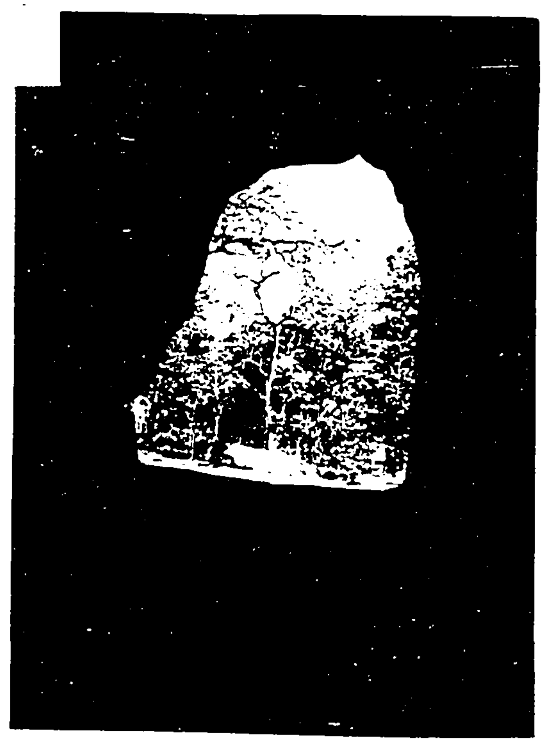


Fig. VI 5. Rock shelter IIIF-23 of Bhimbetka (above), view through the back entrance from inside the rock shelter IIIF-23 (below).

Layer & depth	Nature of the soil	Cores		Discoidal Cores	Bigger flakes	Smaller flakes	Hallow scrapers	Side scrapers	Orates	Hand axes	Cleavers	Borers	Jasper or chalcedony	Total
3	Smaller chips and yellow ochre soil (Muddy appearance)	3	Middle Palaeolithic	18	39	214	14	76	—	—	—	7	—	371
4	Same as above but bright yellow ochre	3		5	220	213	23	85	—	—	—	—	6	555
5A 110 cms	Yellow ochre *Acheulian floor II*	—	Lower Palaeolithic	—	—	138	10	41	—	5	26	—	—	220
5B 175 cms	*Big boulders with* Light red soil like deposit			4	88	285	9	41	—	12	22	—	—	461
5C 210 cms	Red soil & weathered boulders *Acheulian floor I*	—		—	144	134	12	—	13	20	25	—	—	336
6	TOTAL	6		27	347	994	190	243	13	37	73	7	6	1943
6	Reddish black soil huge boulder	No tools												
7	Lateristic deposit weathered boulders	Chopper like pebble tools												

Fig. VI 6. The stratigraphy of Trench II in rock shelter IIIF-24 of Bhimbetka (Wakankar, 1973: Table 3).

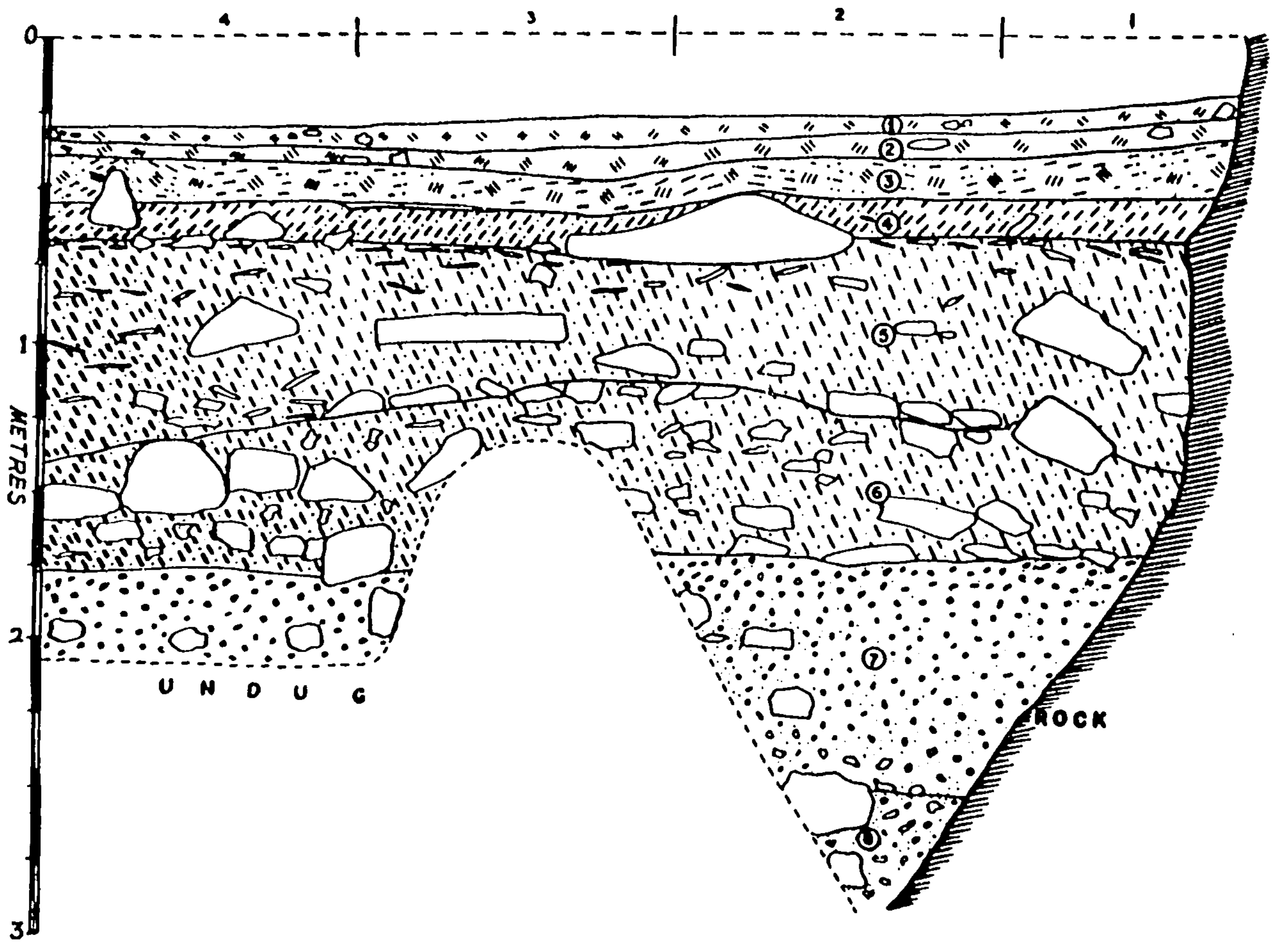


Fig. VI 7. The section between Trenches F & G facing east in rock shelter IIIF-23 of Bhimbetka (Mishra, 1975: Fig. 4).

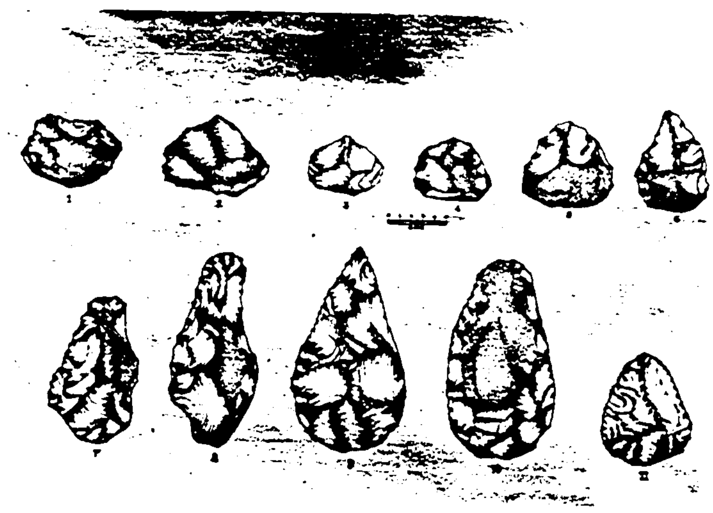




Fig. VI 8. Diagram from the exhibition at the Vikram University Museum (above), the director of the Vikram University Museum, Dr. D. S. Solanki with Dr. C. L. Shannon of Washington University (below).

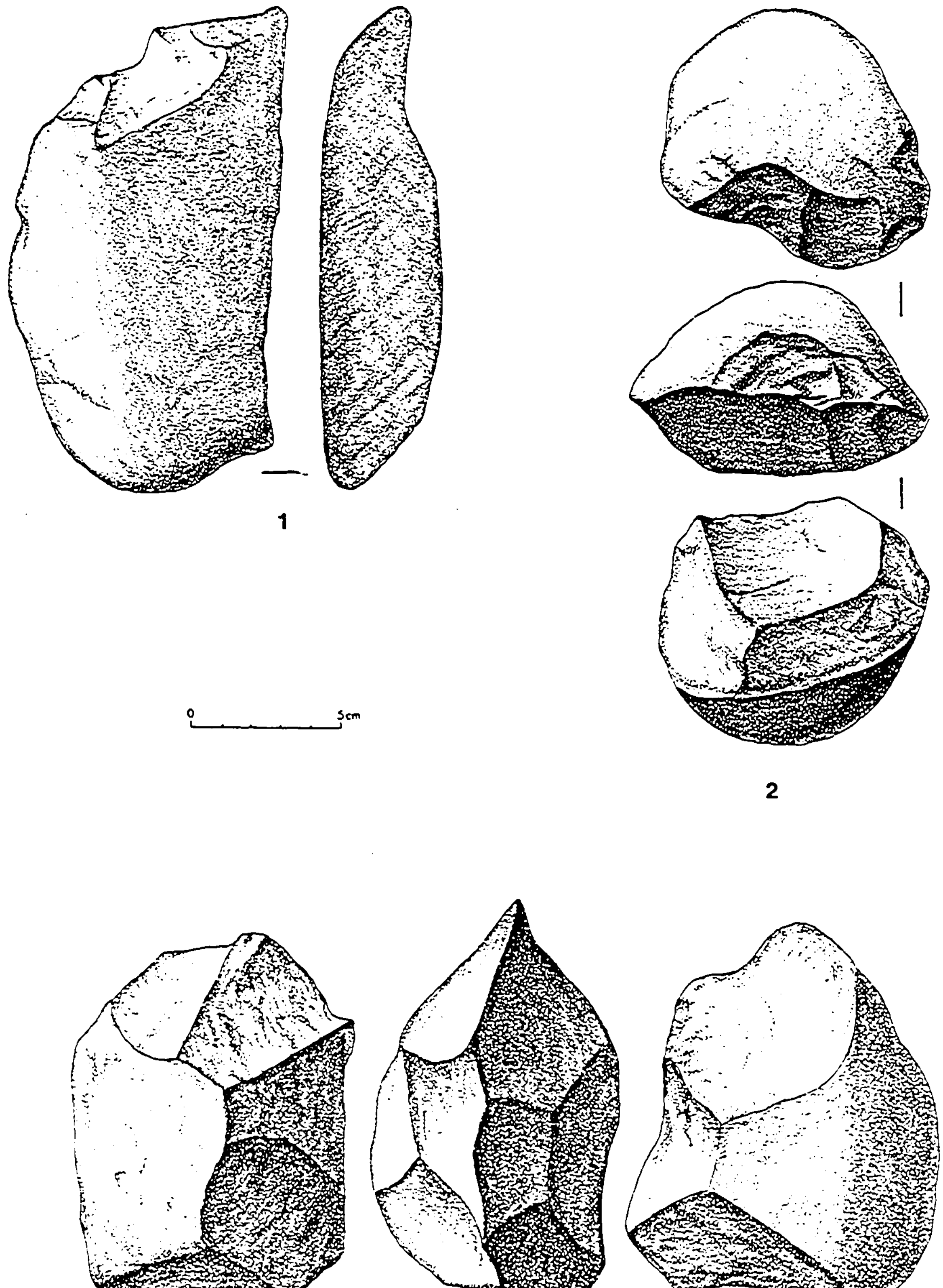


Fig. VI 9. Tools of type C1 (1. Ia:3) and C9 (2. Ia:2 3. Ia: 1) from Bhimbetka.

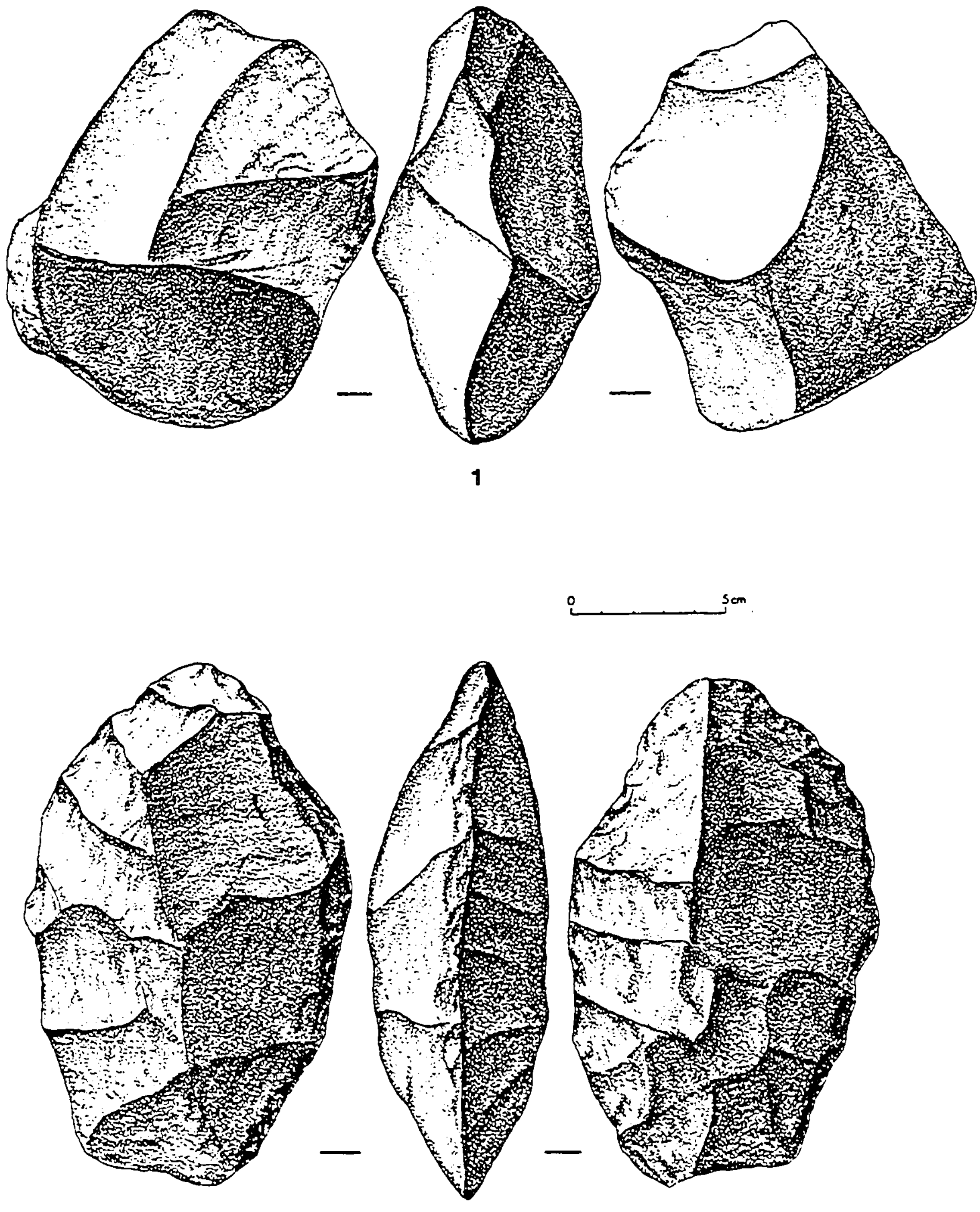


Fig. VI 10. Tools of type C9 (1. Ia:4) and C13 (2. Ia:7) from Bhimbetka..

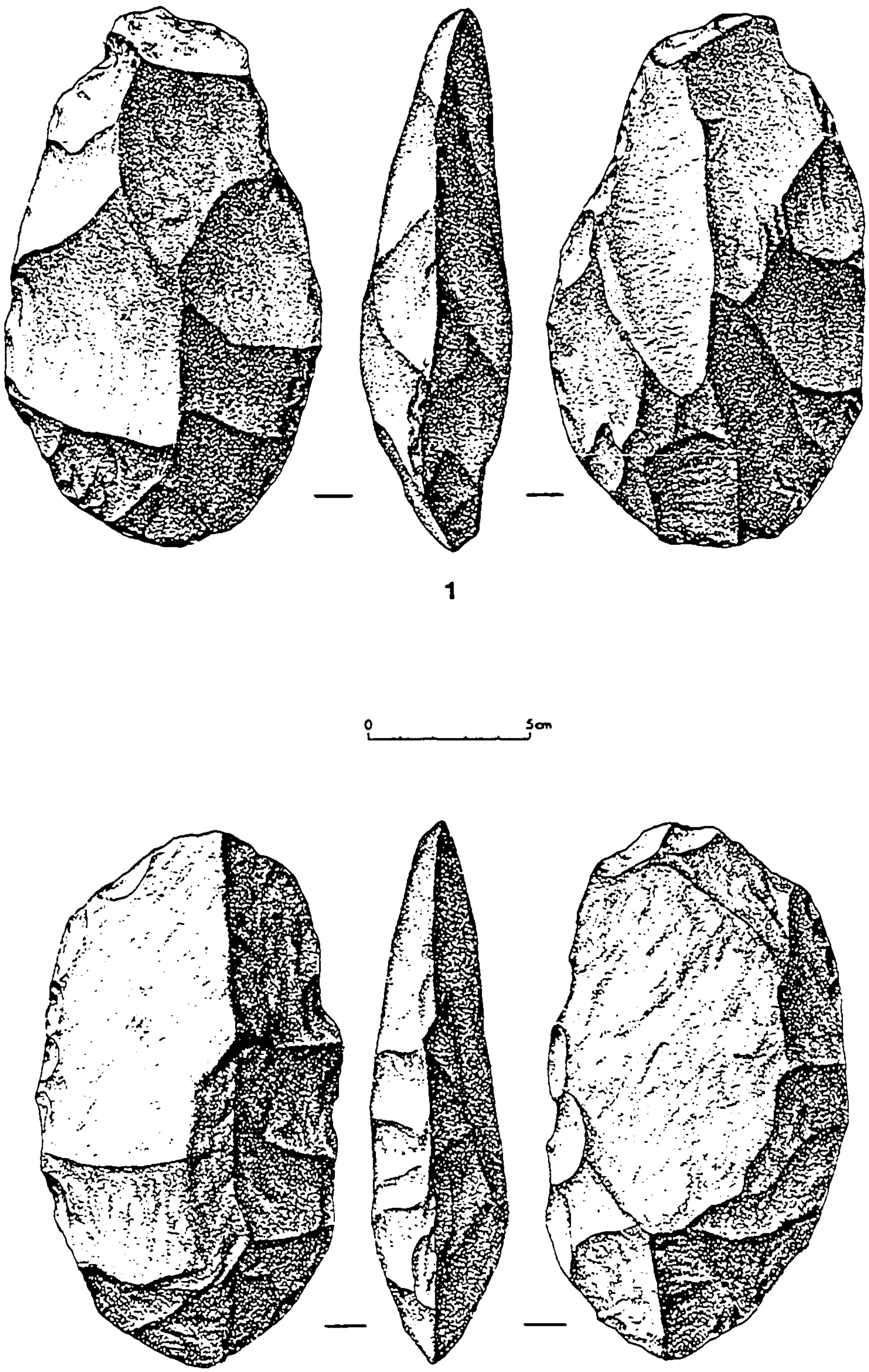


Fig. VI 11. Tools of type C13 (1. Ia:8) and C14 (2. Ib:10) from Bhimbetka.

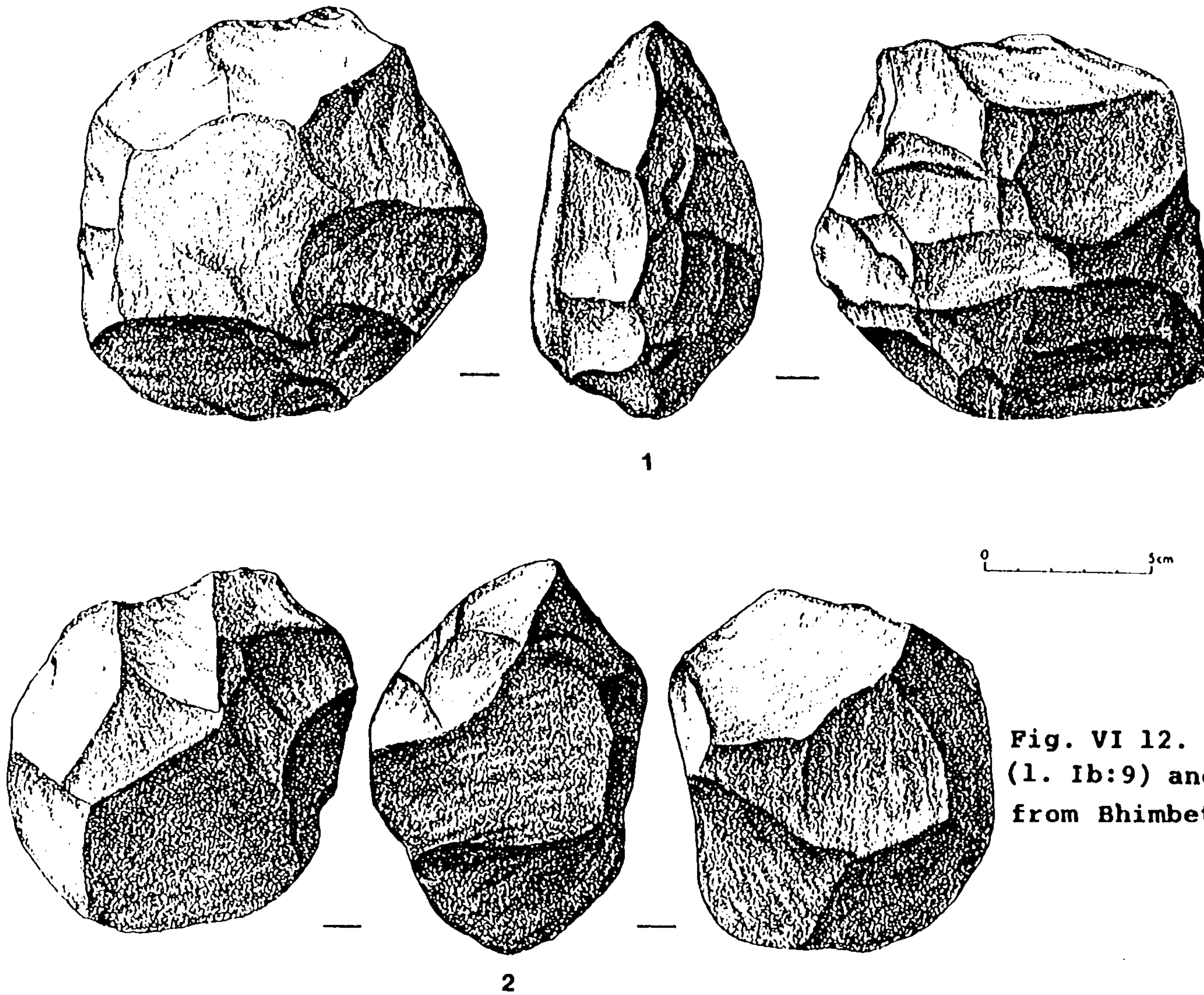


Fig. VI 12. Tools of type C15 (1. Ib:9) and C17 (2. Ia:6) from Bhimbetka.

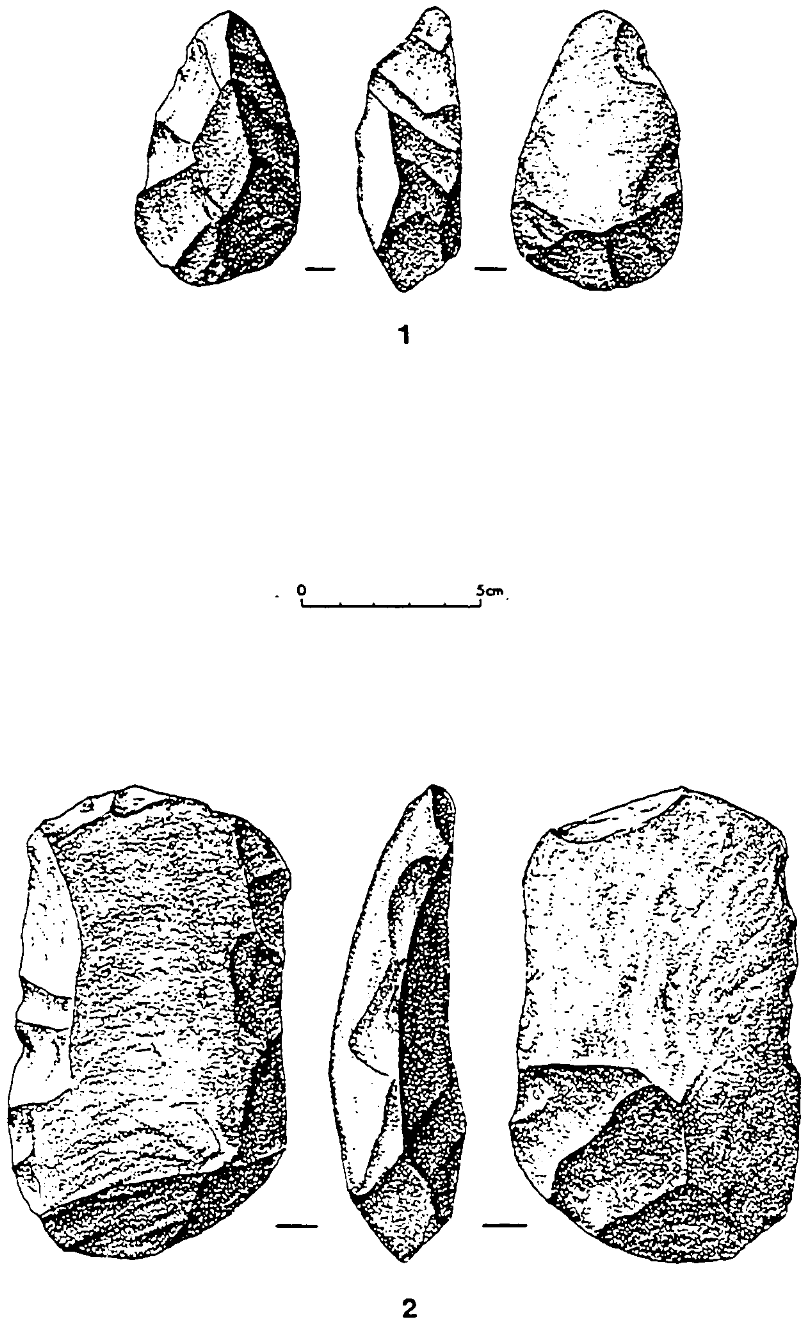
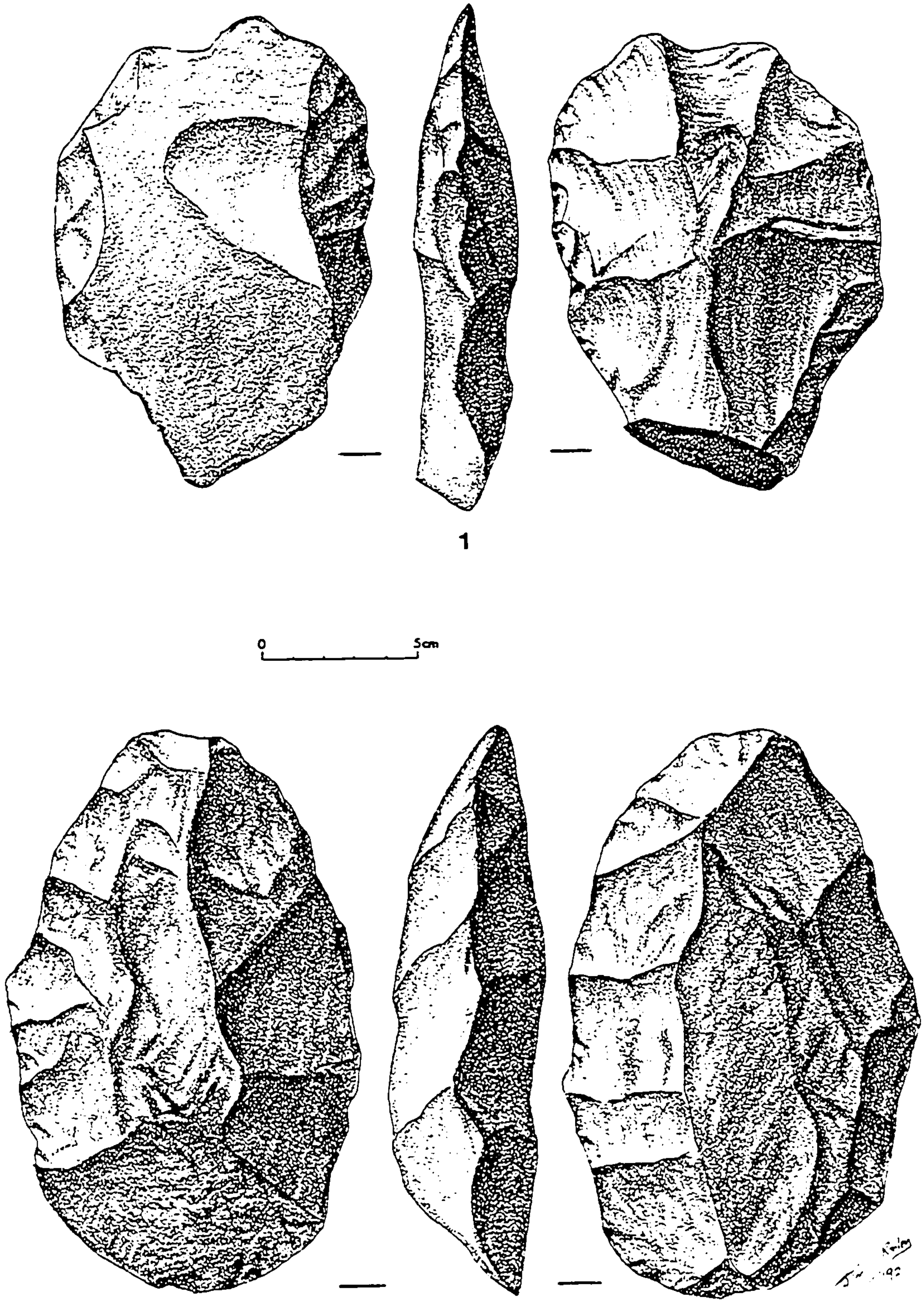


Fig. VI 13. Tools of type F5 (1. Ia:5) and F3 (2. Ib:11) from Bhimbetka.



2

Fig. VI 14. Tools of type F13 (Ib:12) and F16 (Ib:13) from Bhimbetka.



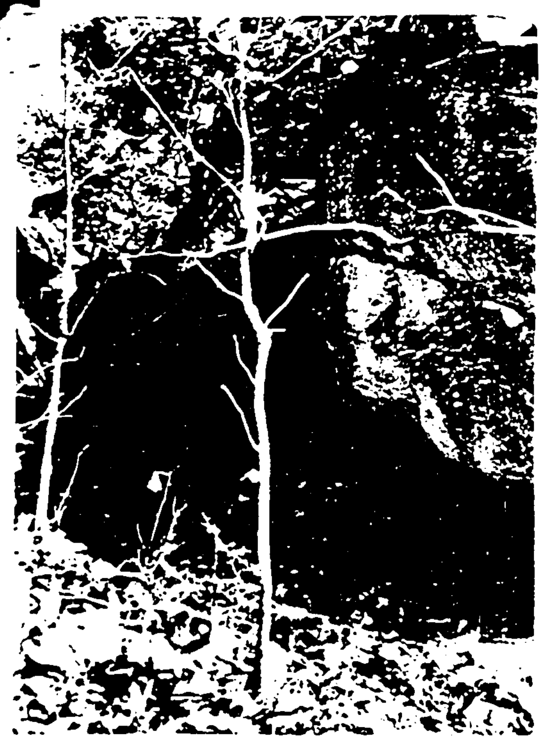


Fig. VI 15. Weathered rock shelters at Bhimbetka.

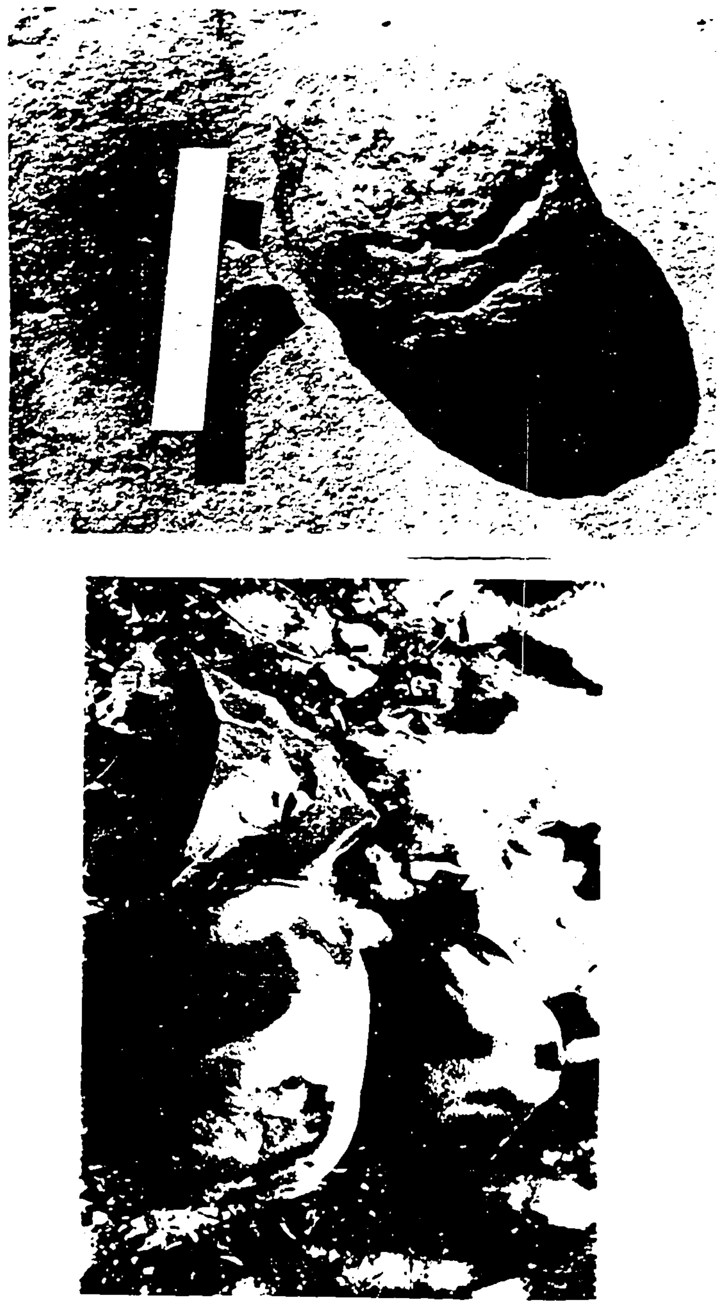


Fig. VI 16. Weathered cobbles or blocks at Bhimbetka (av. size 107x94x75 mm).





Fig. VI 17. Large outcroppings of sandstone at Bhimbetka (15 cm. scale).





Fig. VI 18. The negative flake scars and protruding striking points on an outcropping at Bhimbetka (above), and sandstone blocks and chunks used to make a road at Bhimbetka (below).

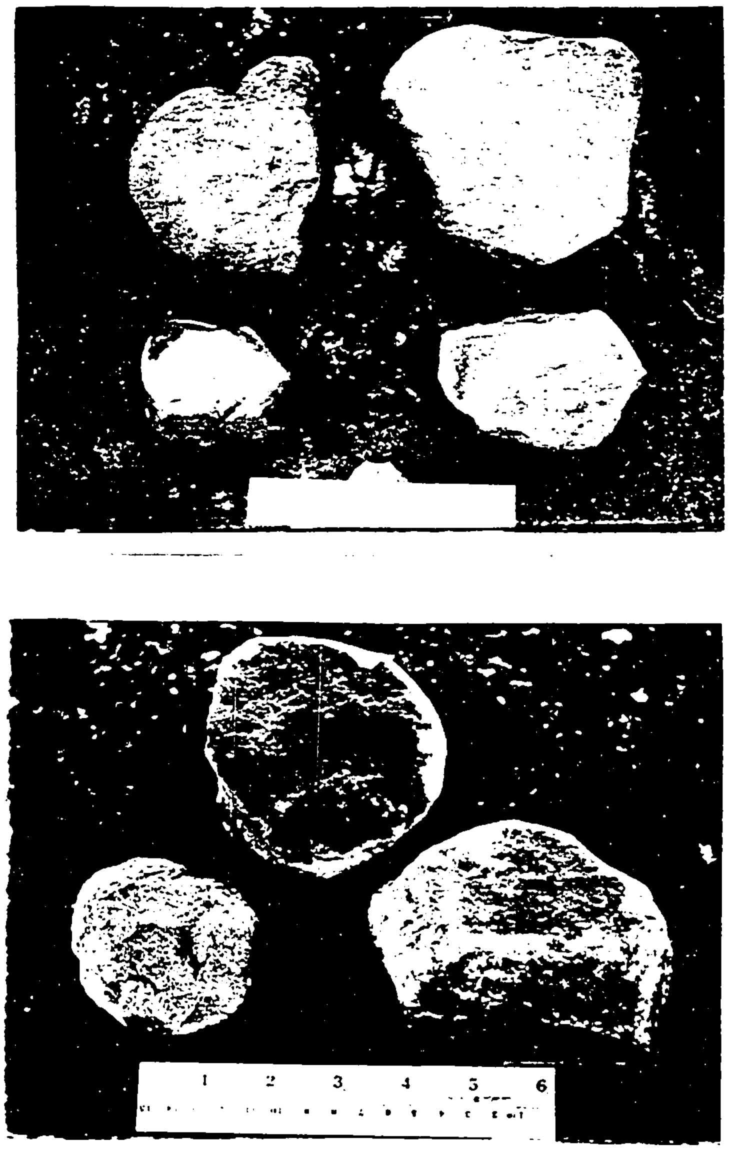
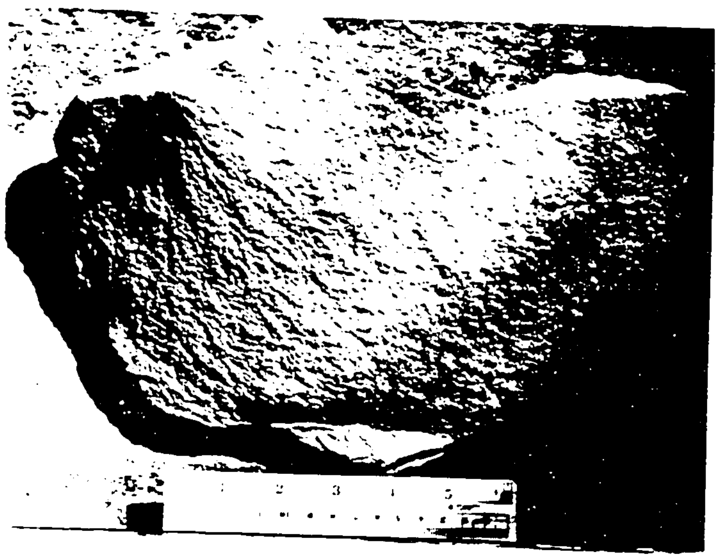


Fig. VI 19. Hammerstones used in the replicative studies at Bhimbetka.



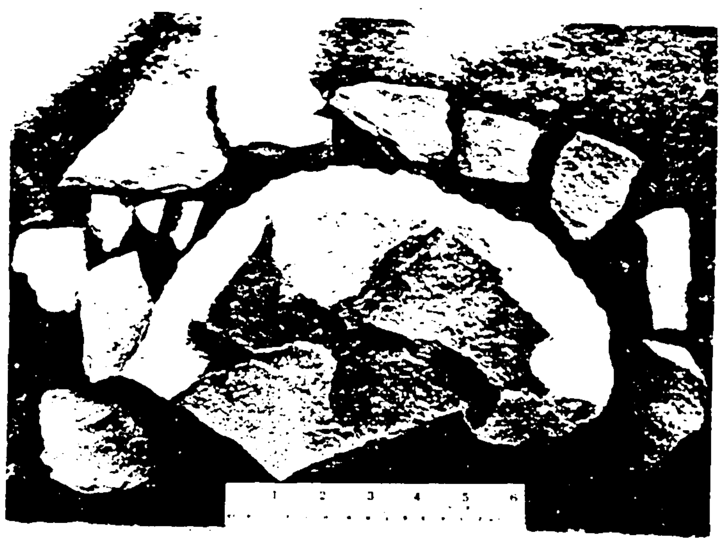
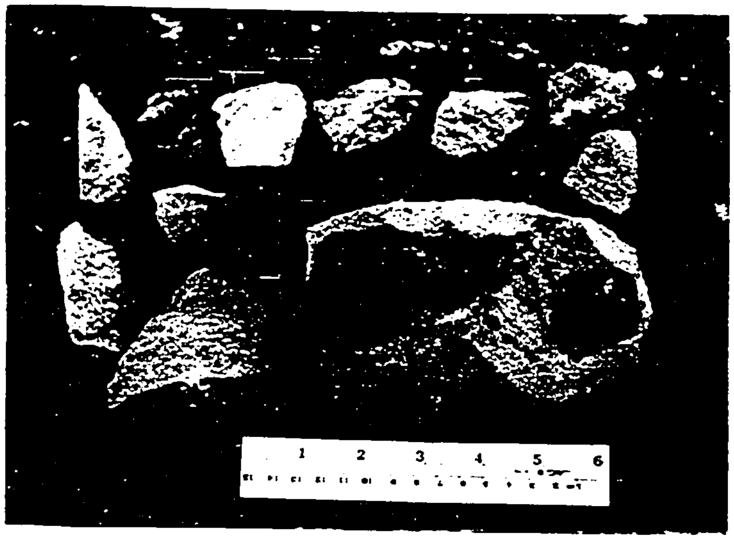


Fig. VI 20. A large flake used in the replicative studies at Bhimbetka (above), and replication: sharpening the distal end (below).



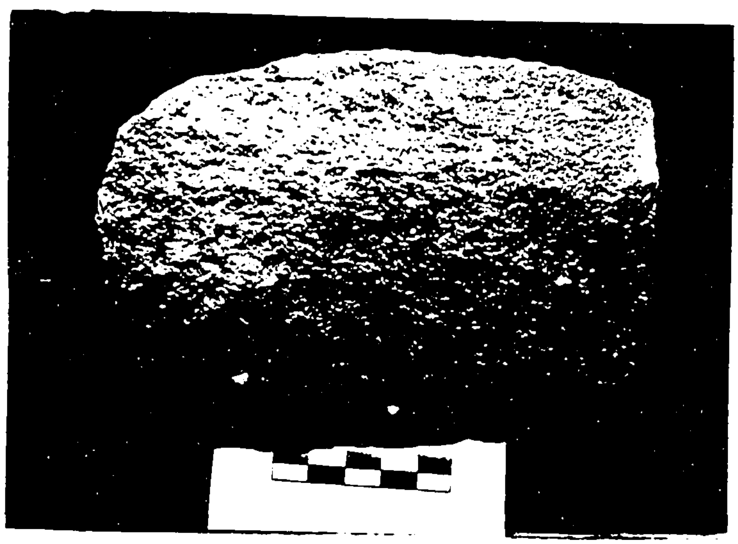


Fig. VI 21. Replication: F3, of Bhimbetka.

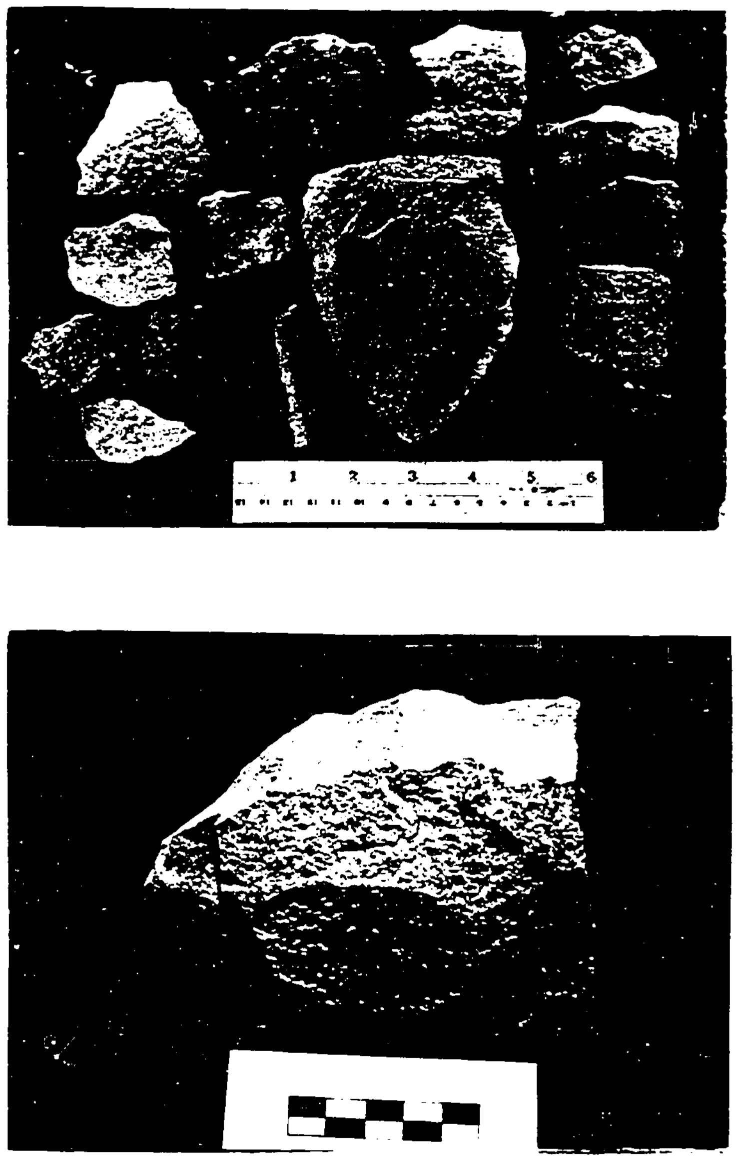


Fig. VI 22. Replication: F13, of Bhimbetka.

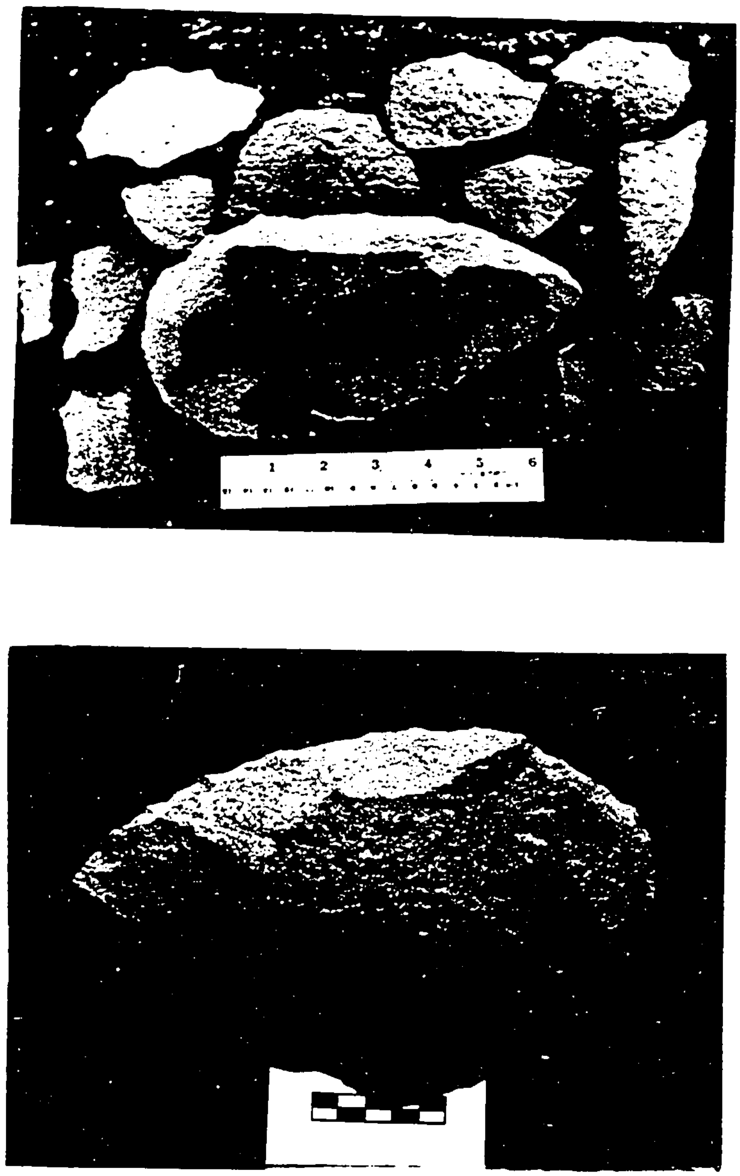


Fig. VI 23. Replication: C13, of Bhimbetka.

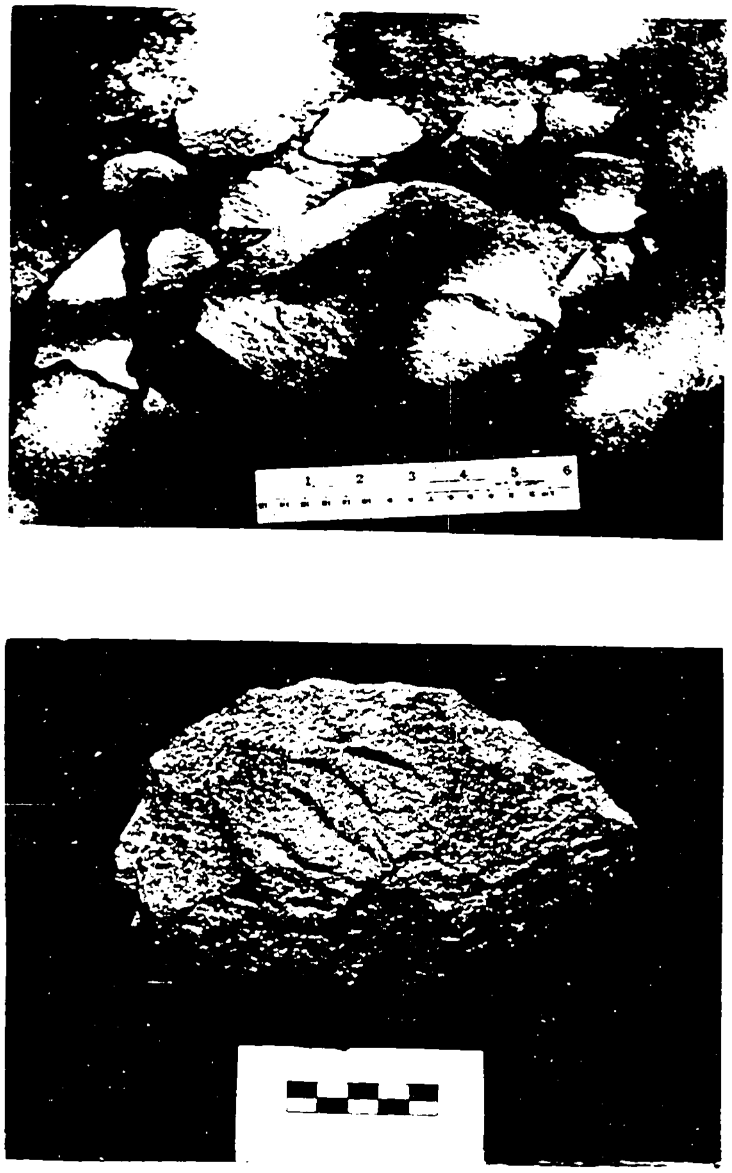


Fig. VI 24. Replication: F16, of Bhimbetka.

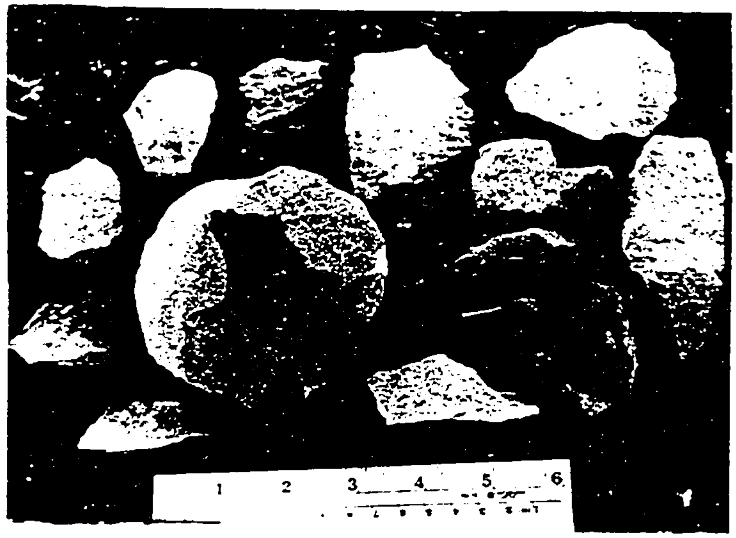




Fig. VI 25. Replication: C15, of Bhimbetka.

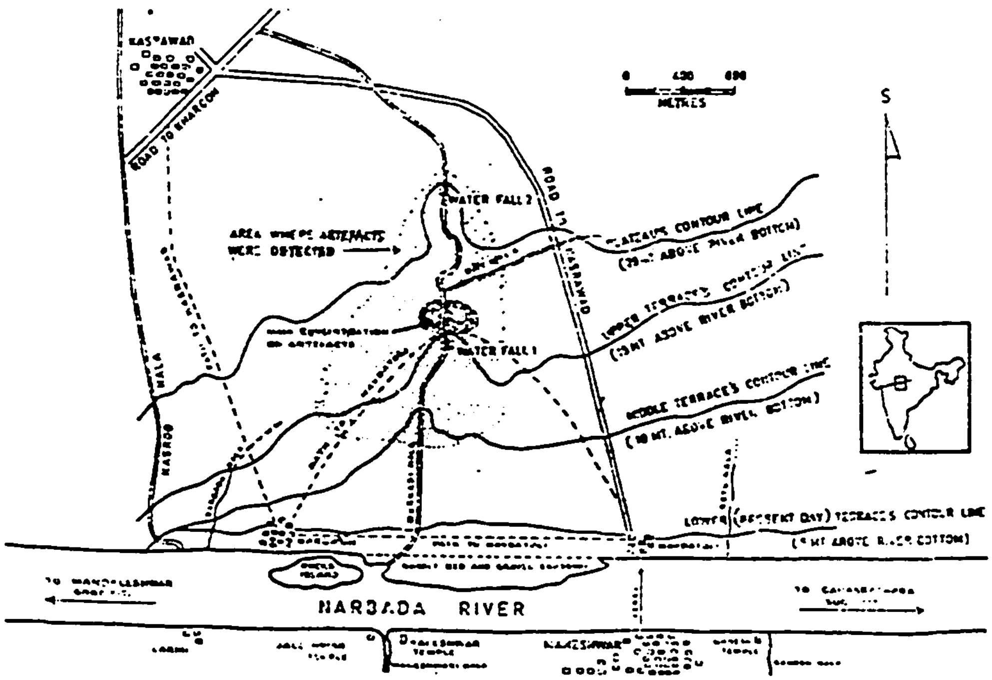


Fig. VII 1. Map of the Durkadi Nala site (Armand, 1983: Fig. 1).

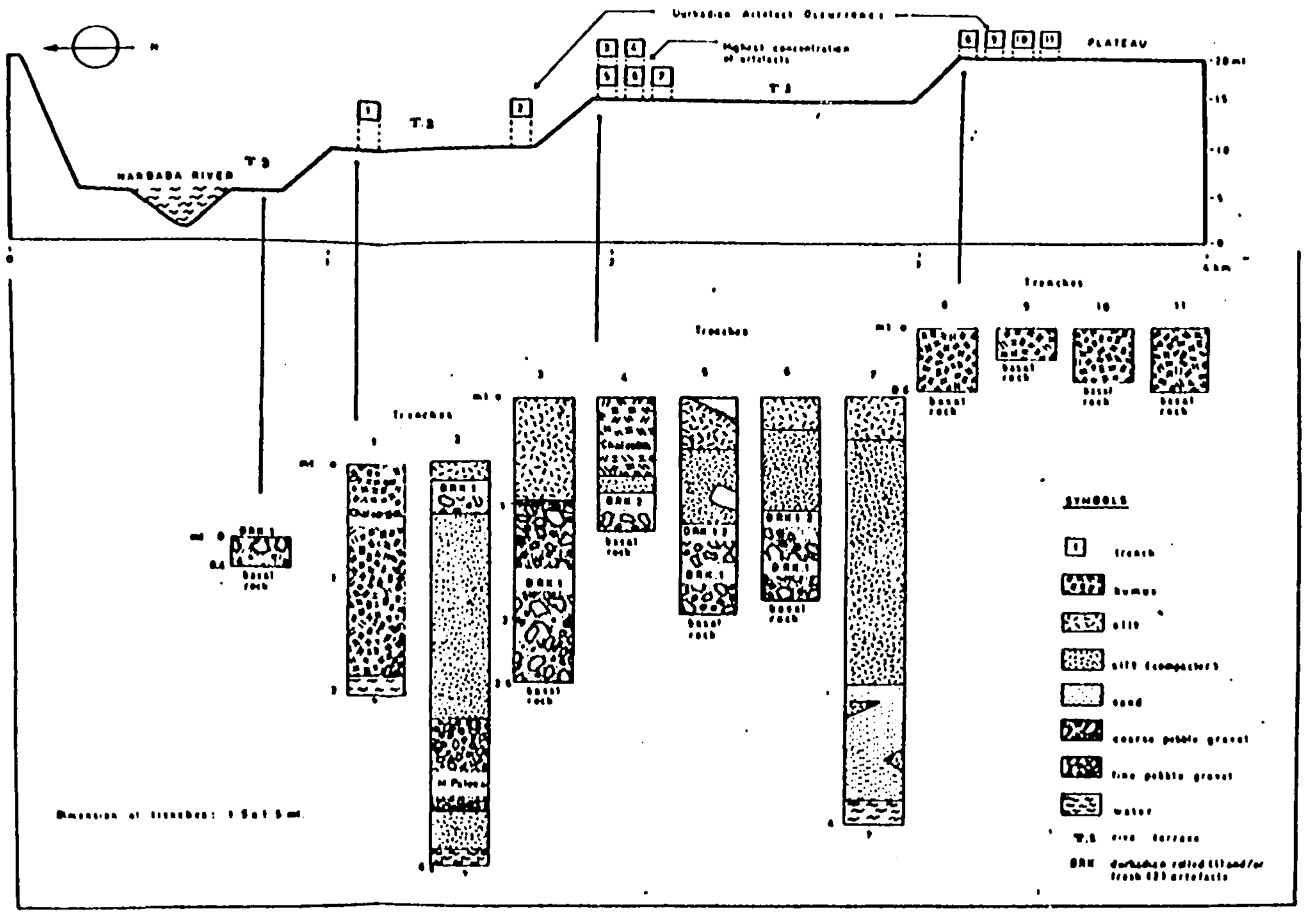


Fig. VII 2. Transversal profile of the Narmada River Valley across the Durkadi brook showing a terrace-wise stratigraphic sequence of the area, the extension of the pebble artifacts occurrence, and the distribution of the excavated trenches (Armand, 1983: Fig. 2).

Terrace	*Geological layer*	*Climatic stage*	*Cultural stage*	*Age*
1, 2 and *Plateau*	"Black soil"	Post-pluvial	Chalcolithic	Holocene
3	Gravel III[2]	4th pluvial	Upper Palaeo-lithic[3]	Upper Pleistocene
2[4]	Silt II Gravel II	3rd inter pluvial 3rd pluvial	Middle Palaeolithic[5]	
	Silt I	2nd inter-pluvial	Lower Palaeo-lithic	Middle Pleisto-cene
1	Gravel 1	2nd pluvial		
Plateau	?	1st inter-pluvial	?	Lower Pleisto-cene
—	Bed rock	—	—	—

[2]The gravel found on Terrace 3 is perhaps partially formed by elements from gravels I and II, redeposited by colluvial erosion (?)

[3]No artefact belonging to Upper Palaeolithic has been found so far in Durkadi.

[4]Stratigraphy of Terrace 1 (upper) was clearly defined on the basis of five trial trenches and an extensive horizontal excavation; while that of Terrace 2 (middle) is still confused as bed rock here was not attained by excavation nor seen at any natural section.

[5]Only few artefacts belonging to the middle Palaeolithic have been found so far in Durkadi.

Fig. VII 3. General Pleistocene evolution in Durkadi: A hypothesis (Armand, 1983: Table 14).

Geological layer	Depth (mt)[1]	Cultural occurrence
"Black Soil"	0 to 1	Chalcedony blades, pottery sherds, bone necklace beads of Navdatolian style (Chalcolithic)
Silt colour D42 ("light red brown")	0 to 6[2]	STERILE
Course pebble gravel	0 to 1.3: (*a*) top 35 cm: (cemented)	Quartzite pebble artefacts. *Near 75% of specimens are fresh* (lower Palaeolithic)
	(*b*) below top 35 cm: (non-cemented)	Quartzite pebble artefacts. All *specimens are rolled* (lower Palaeolithic)
Basalt Bed	—	—

[1]The depth of the geological layers varies according to the degree of erosion produced by the Durkadi brook in the different spots. Thus '0' means that the layer was completely eroded and the underlying layer is exposed.

[2]In some spots this layer shows bands of fine clay, lenticular patches of coarse sand or intercalated thin bands of fine pebble. Its colour was determined with the "ex-Polaire" soil chart.

Fig. VII 4. Stratigraphy of Terrace 1 (Upper) of the Narmada River Valley in Durkadi (Armand, 1983: Table 2).

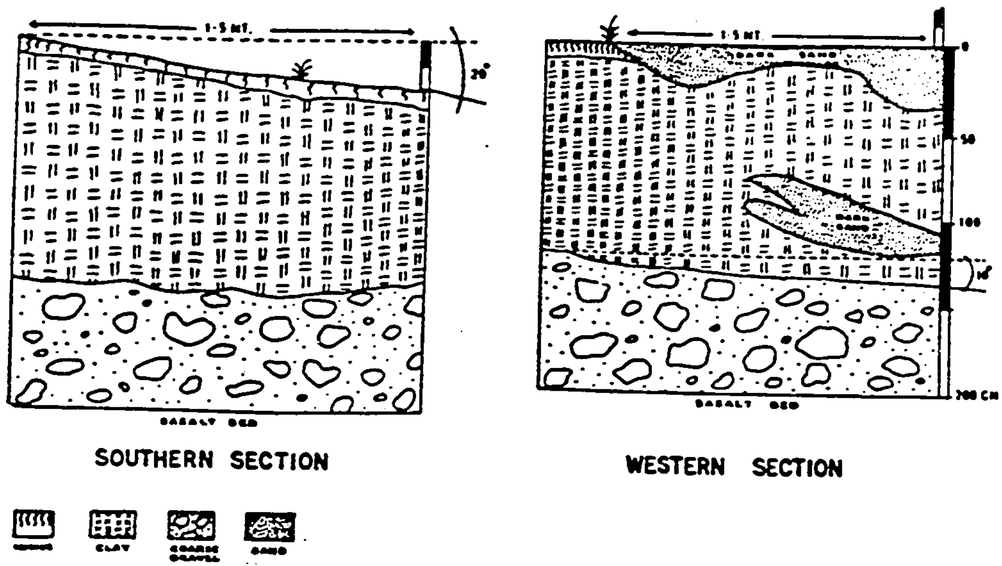


Fig. VII 5. Stratigraphy of Terrace 1 (Upper) as shown in trench No.5 (Armand, 1983: Fig. 6).

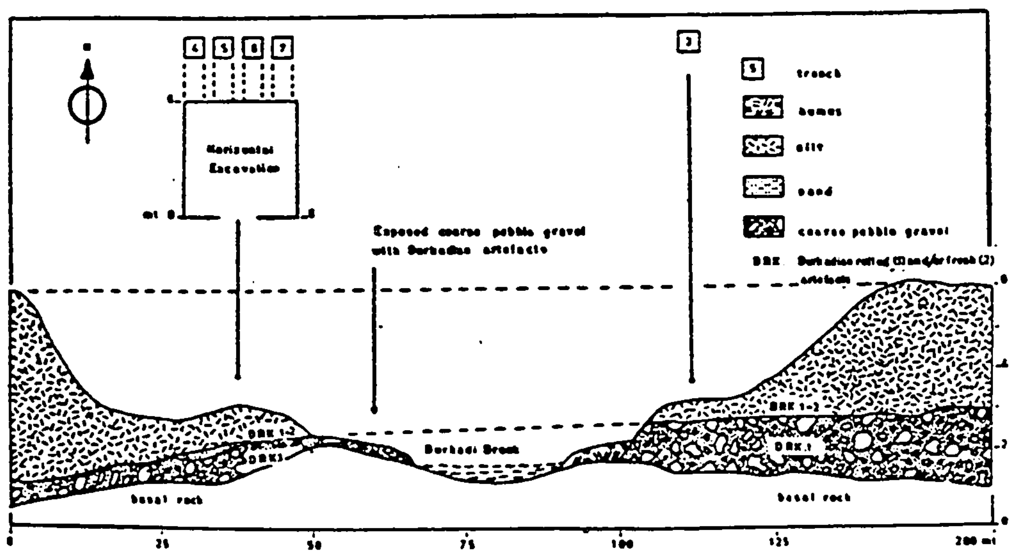


Fig. VII 6. Transversal profile of the Durkadi brook near the edge of Terrace 1 (Upper). showing the stratigraphy of this spot and the emplacement of the horizontal excavation and of trenches Nos. 4 to 7 (Armand, 1983: Fig. 8).

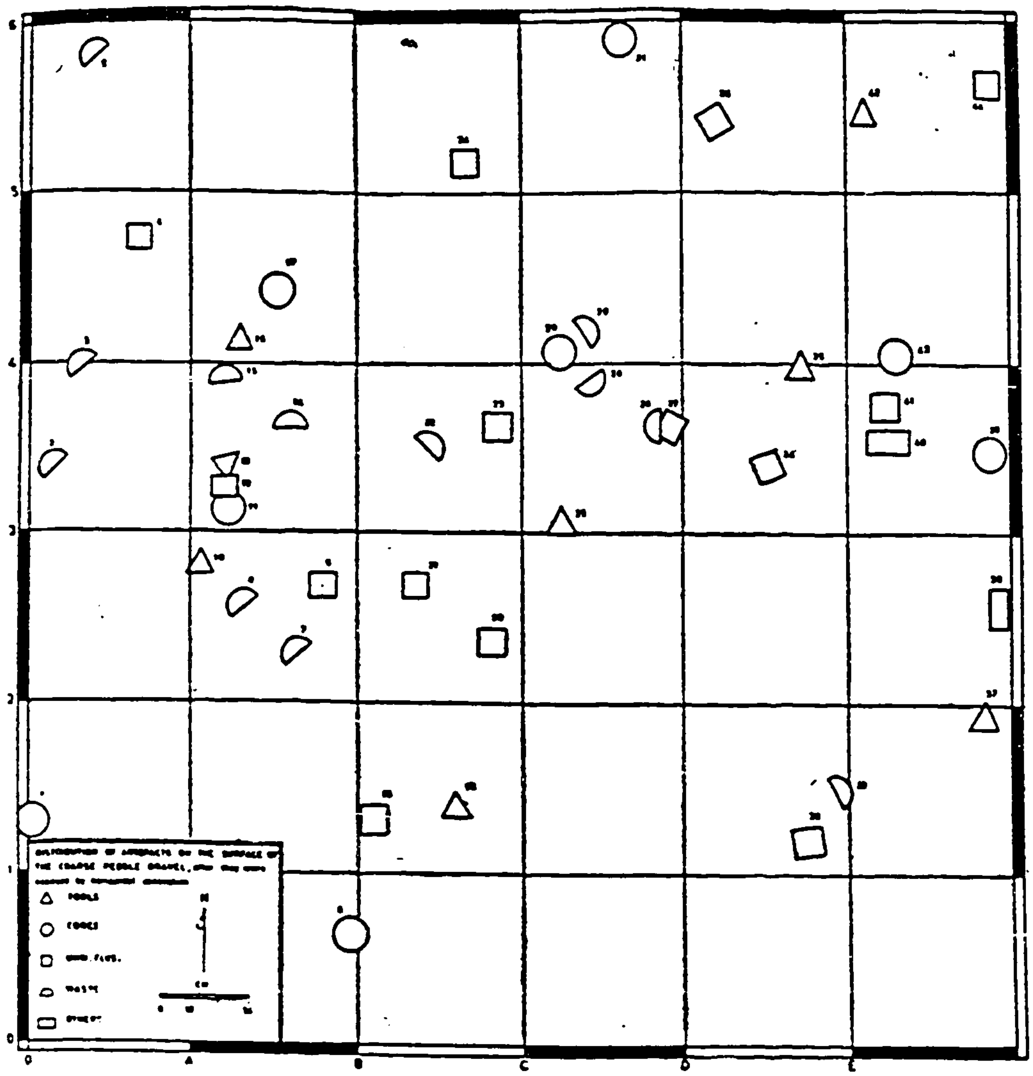


Fig. VII 7. Distribution of artifacts on the surface of the Coarse pebble gravel, after they were exposed by horizontal excavation (Armand, 1983: Fig. 13).



Fig. VII 8. Armand's collections were stored in large boxes.

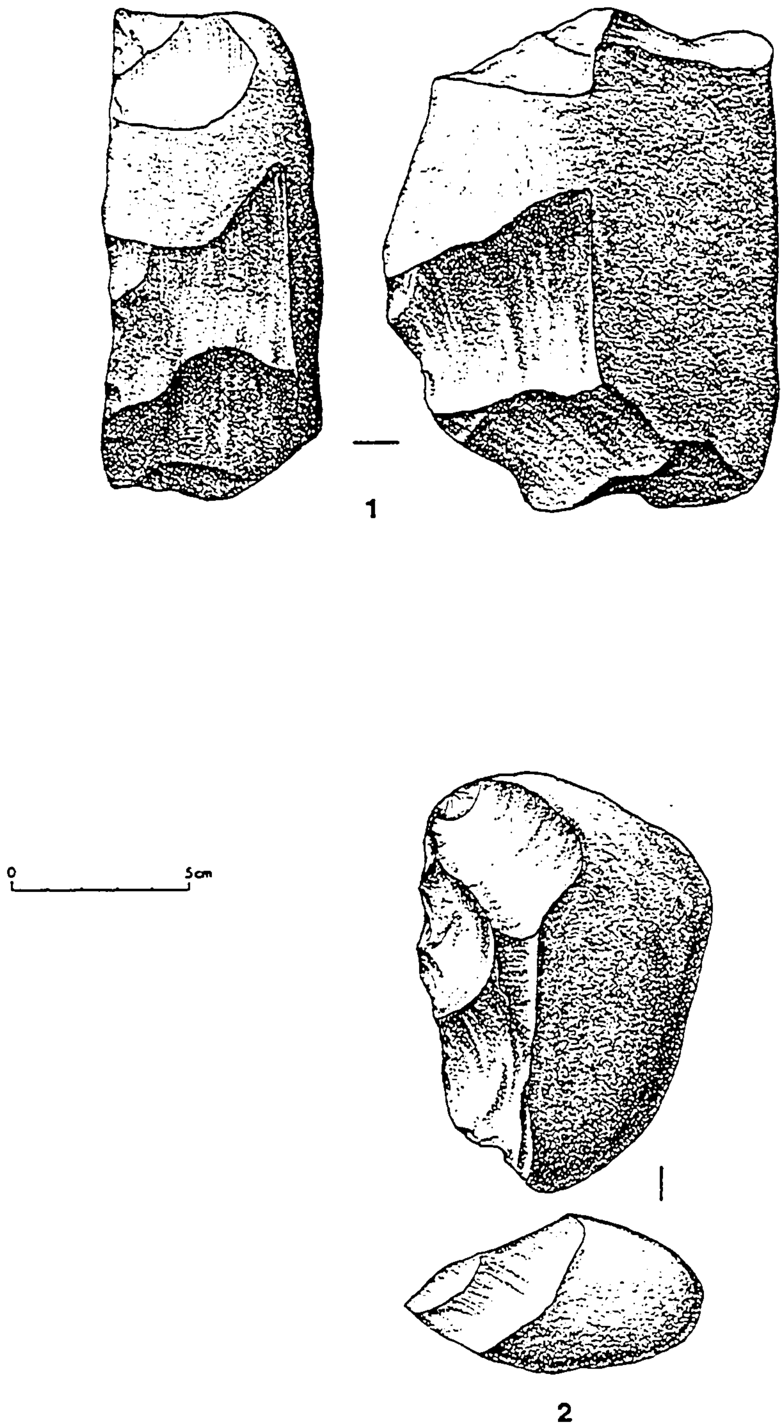
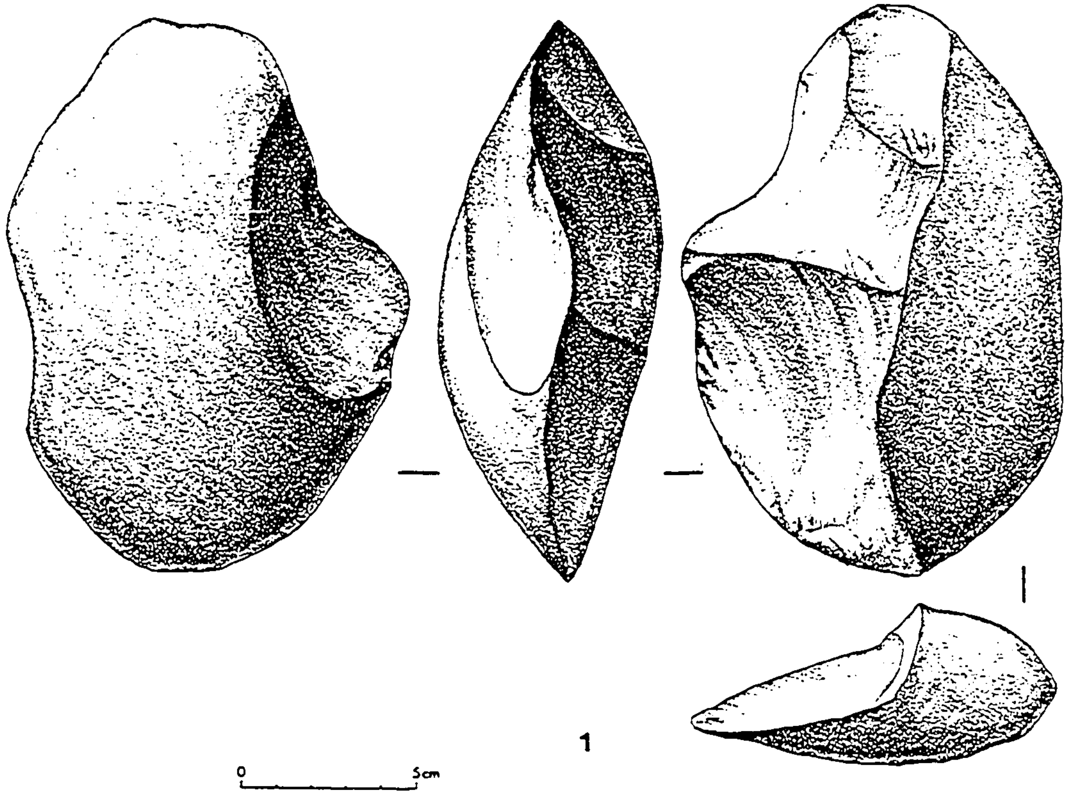
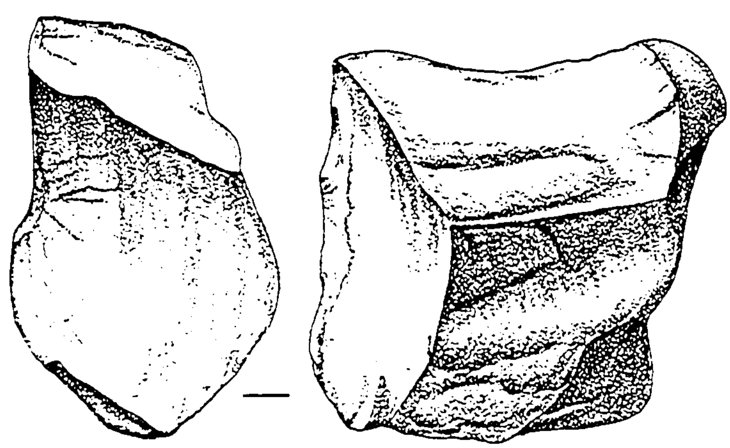


Fig. VII 9. Tools of type C3 (1. 00596) and C1 (2. 00818) from Durkadi.



1



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Fig. VII 10. Tools of type C9 (1. 00530) and C8 (2. 00586) from Durkadi.

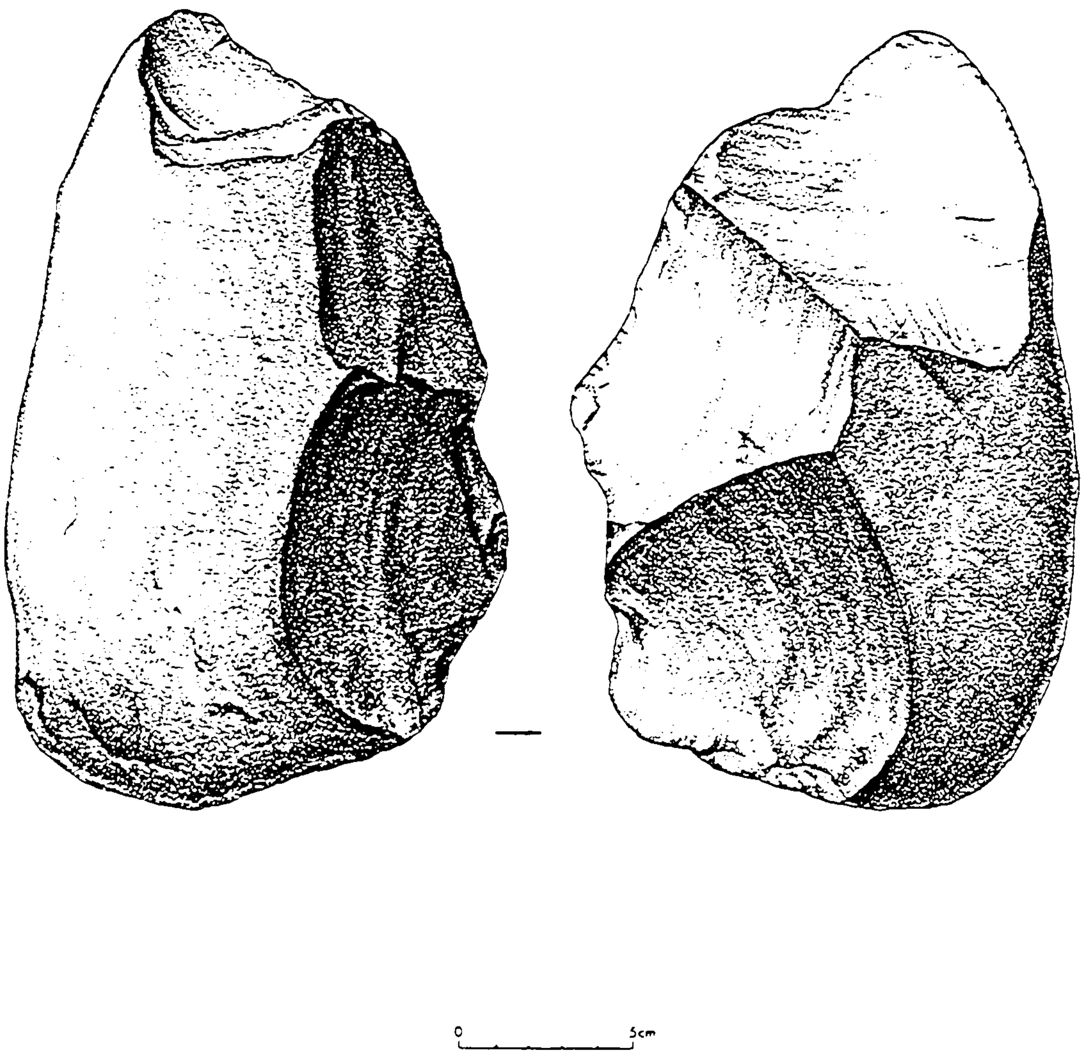


Fig. VII 11. Tool of type C9 (00001) from Durkadi.

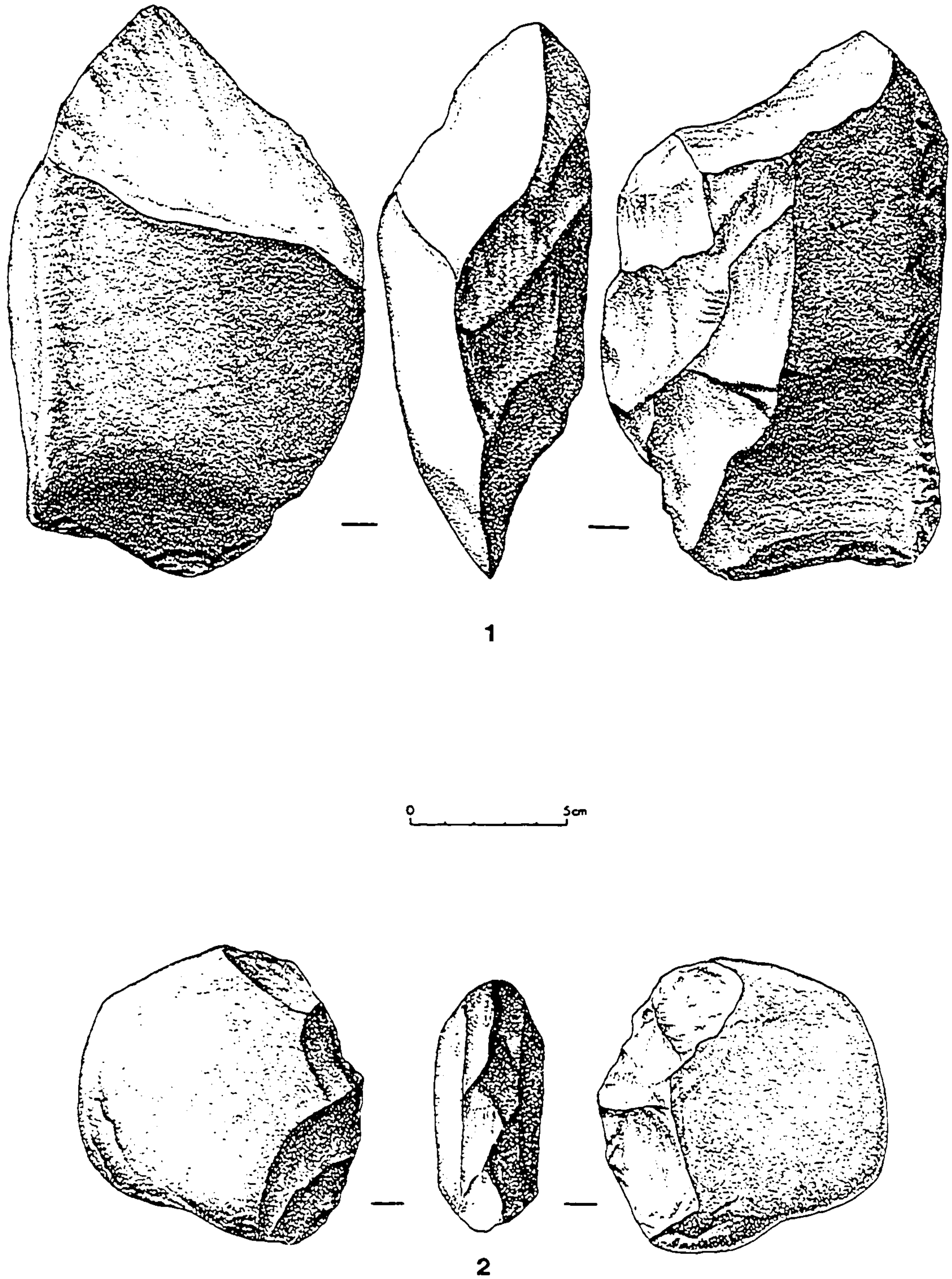


Fig. VII 12. Tools of type C9 (1. 1971 A 2. 00047) from Durkadi.

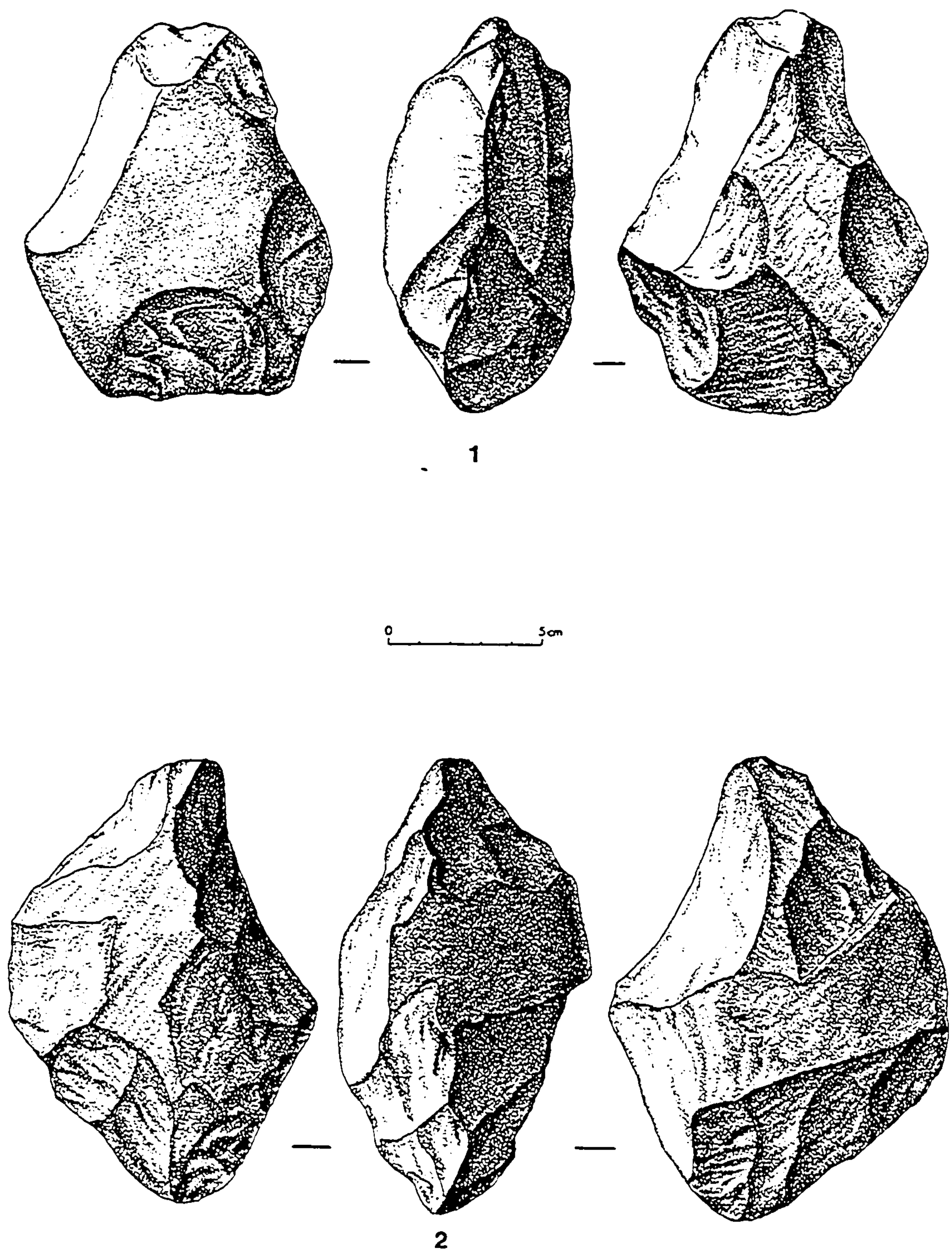
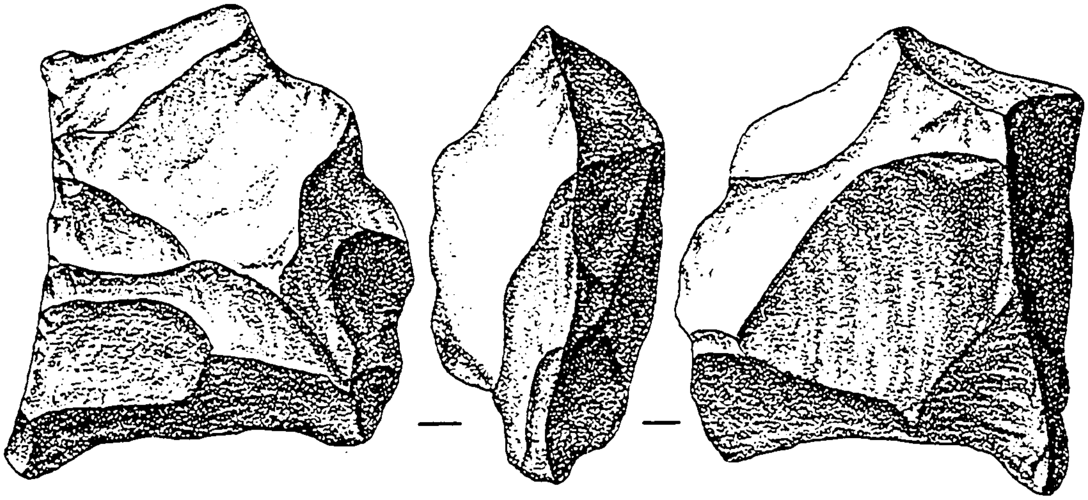
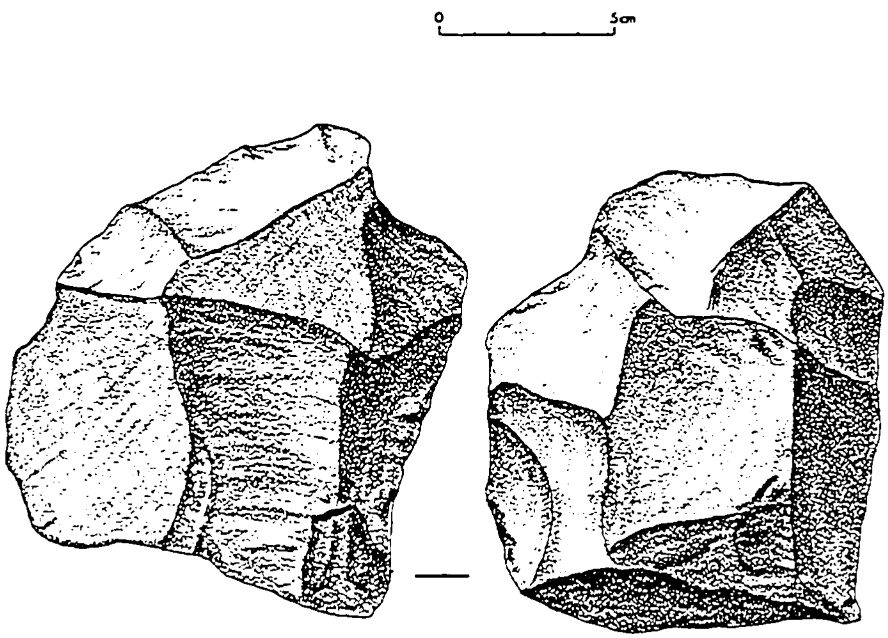


Fig. VII 13. Tools of type C13 (1. 00571) and C14 (2. 00593) from Durkadi.



1



2

Fig. VII 14. Tools of type C17 (1. 00187 2. 00559) from Durkadi.

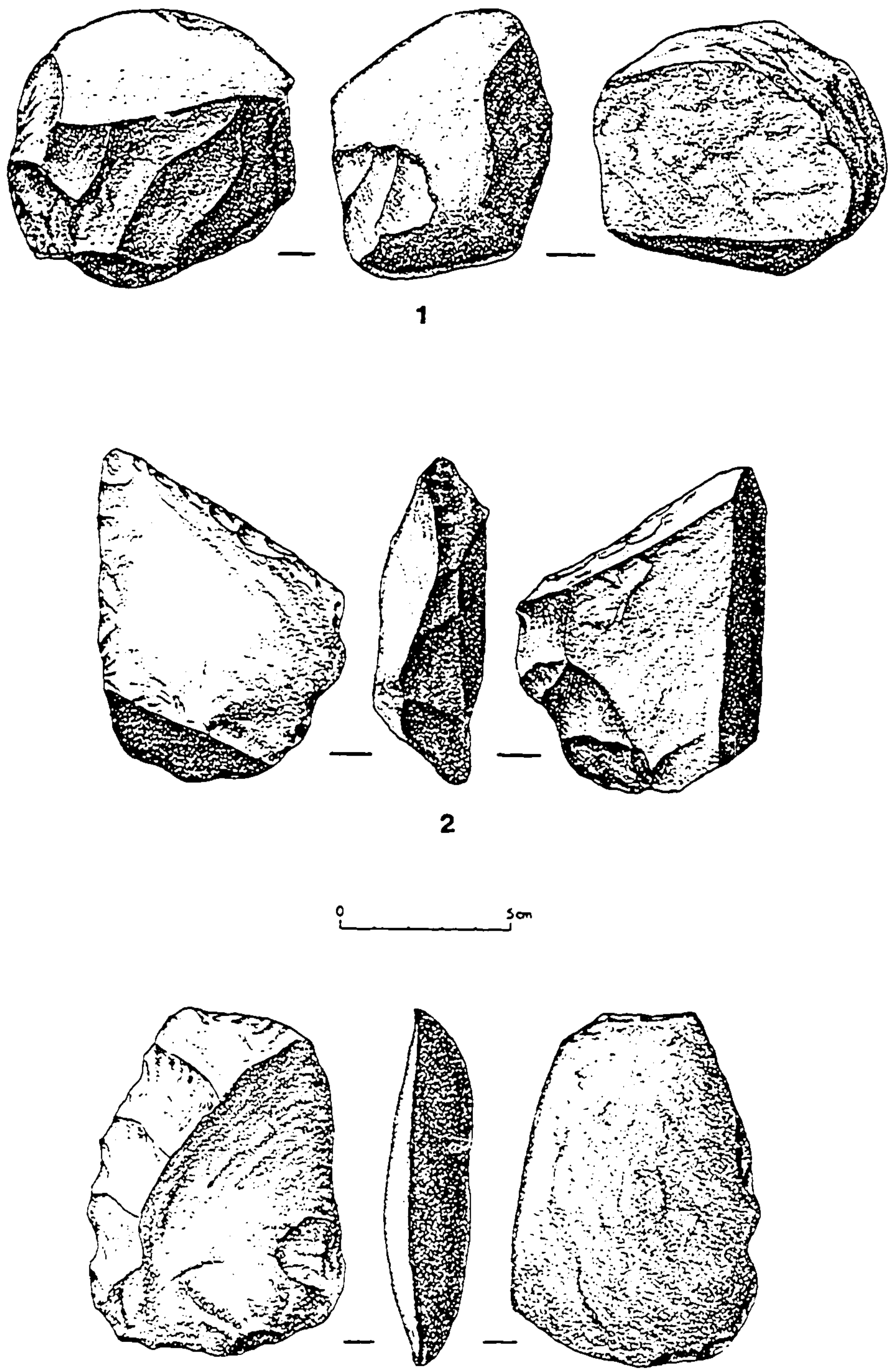


Fig. VII 15. Tools of type C17 (1. 00373) and F1 (2. 00352 3. 00329) from Durkadi.

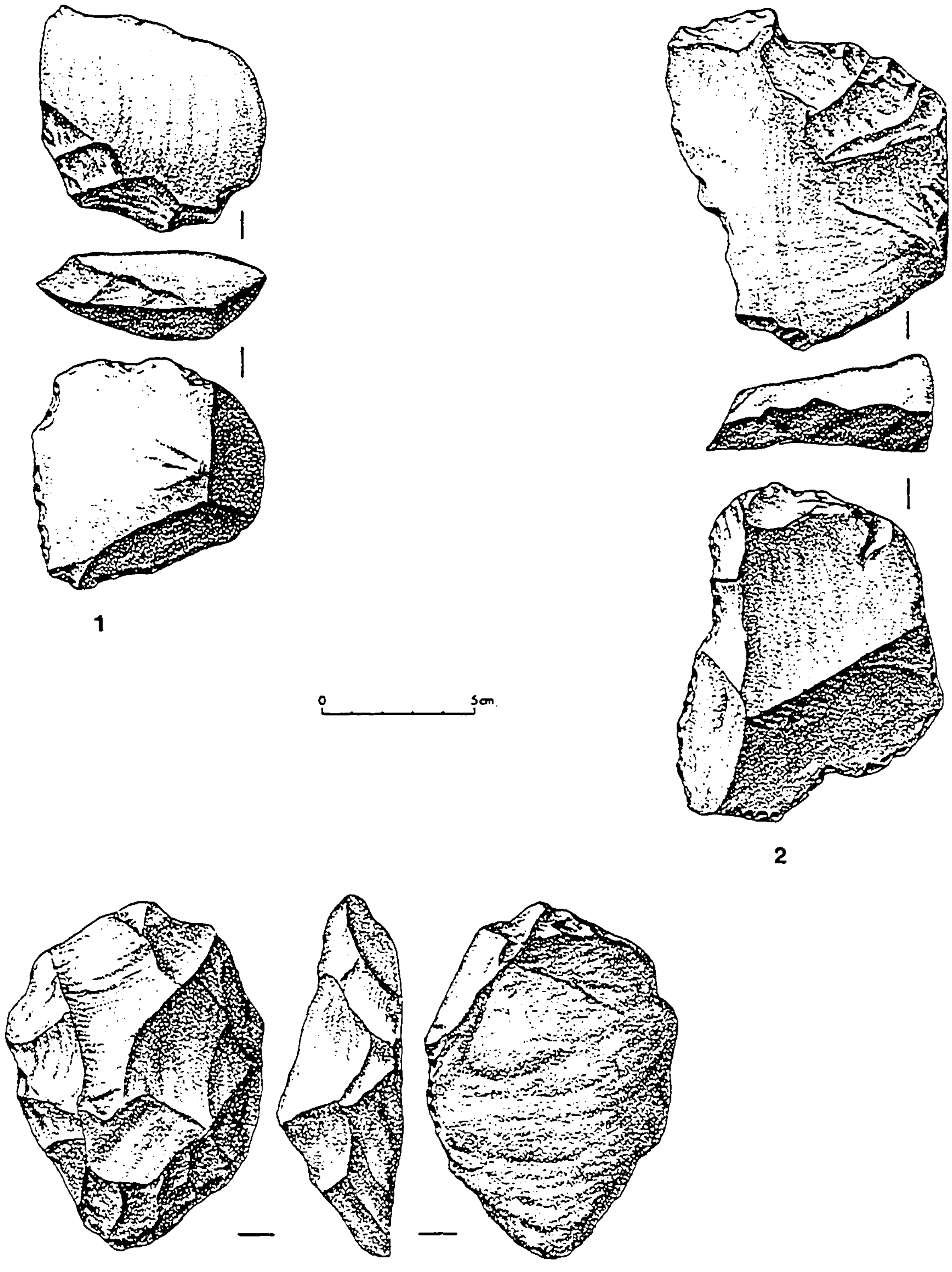


Fig. VII 16. Tools of type F1 (1. 00354), F3 (2. 00221) and F5 (3. 00361) from Durkadi.

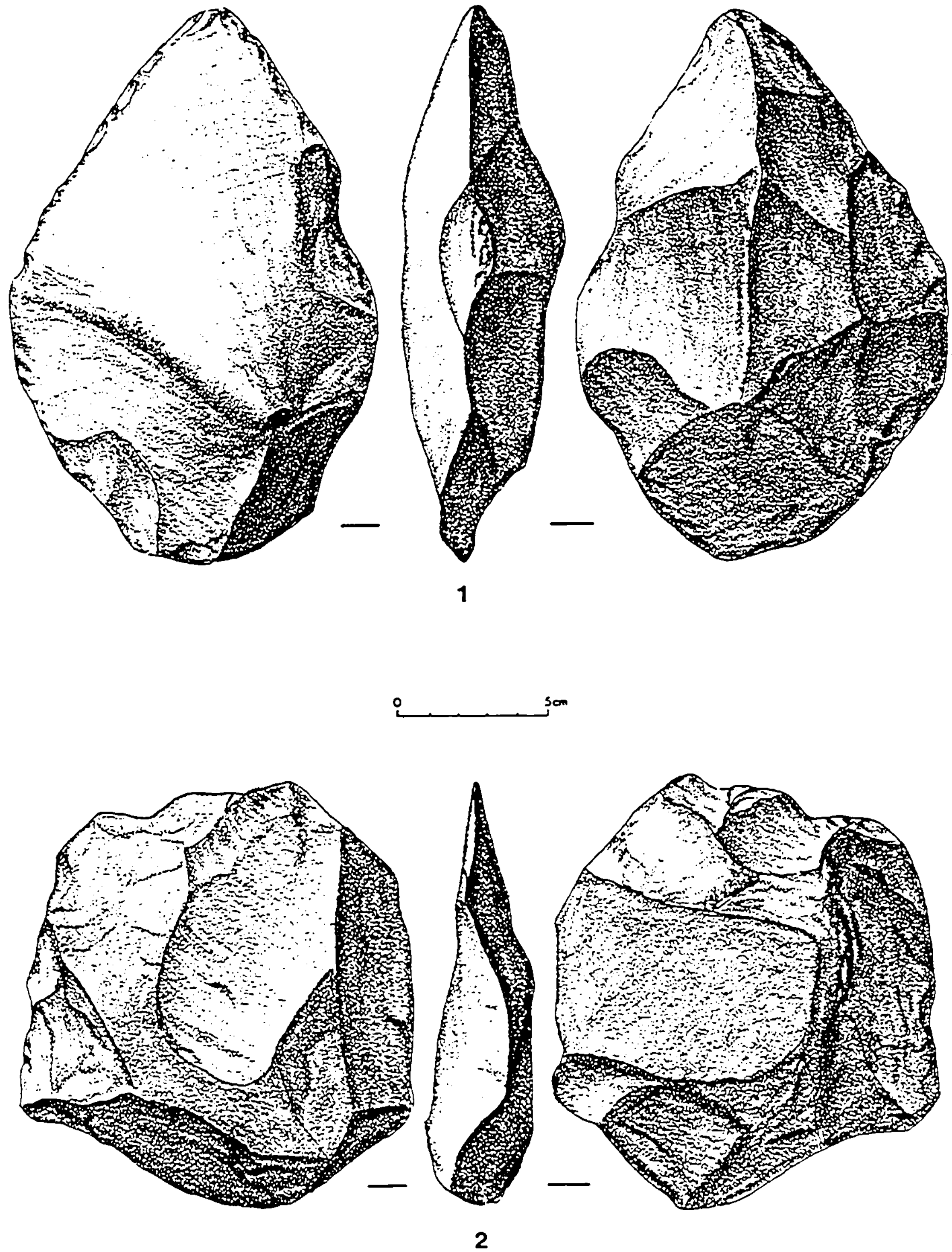


Fig. VII 17. Tools of type F5 (1. 00555) and F14 (2. 00056) from Durkadi.

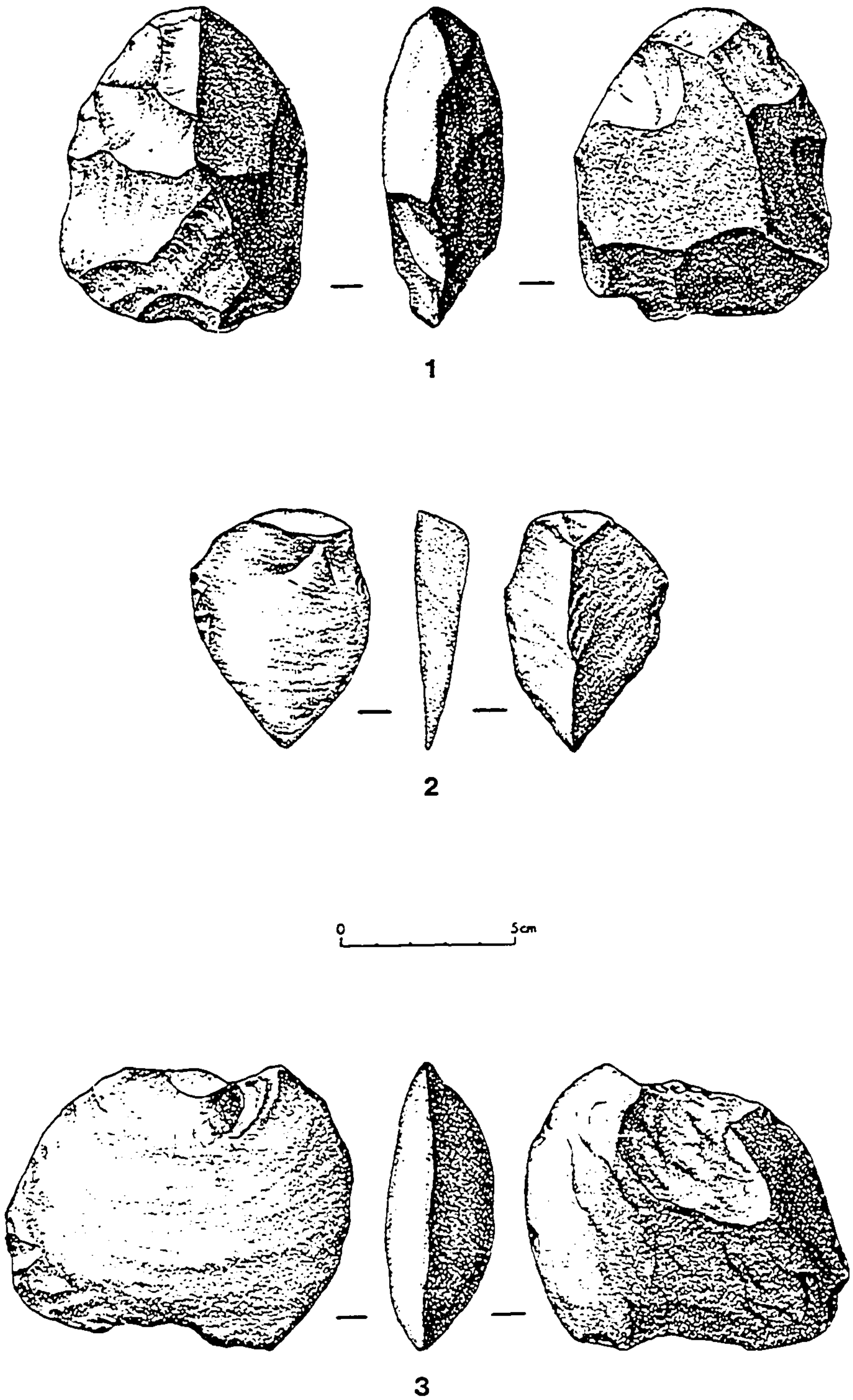


Fig. VII 18. Tools of type F19 (1. 00358) and U1 (2. 00179 3. 00727) from Durkadi.

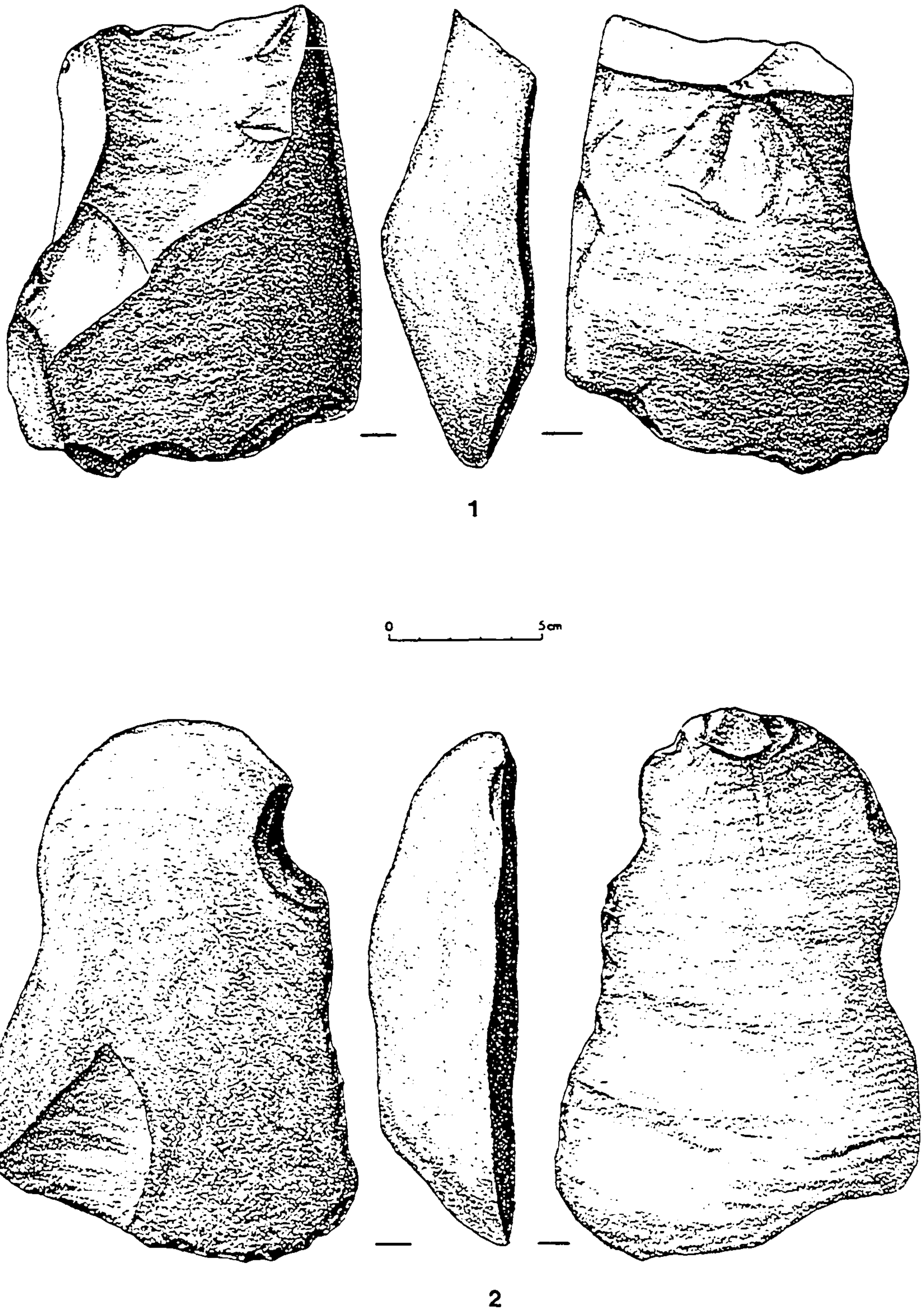


Fig. VII 19. Tools of type U1 (1. 00707 2. 1971) from Durkadi.





Fig. VII 20. Narmada River (above), cobbles covered the south bank of the Narmada River (below).



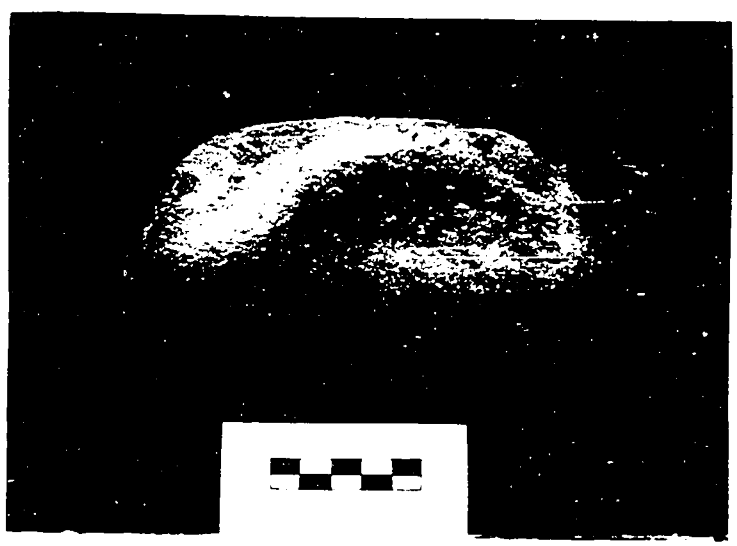


Fig. VII 21. The excavation area at present (above), cobbles used in the replicative studies of Durkadi site (below).

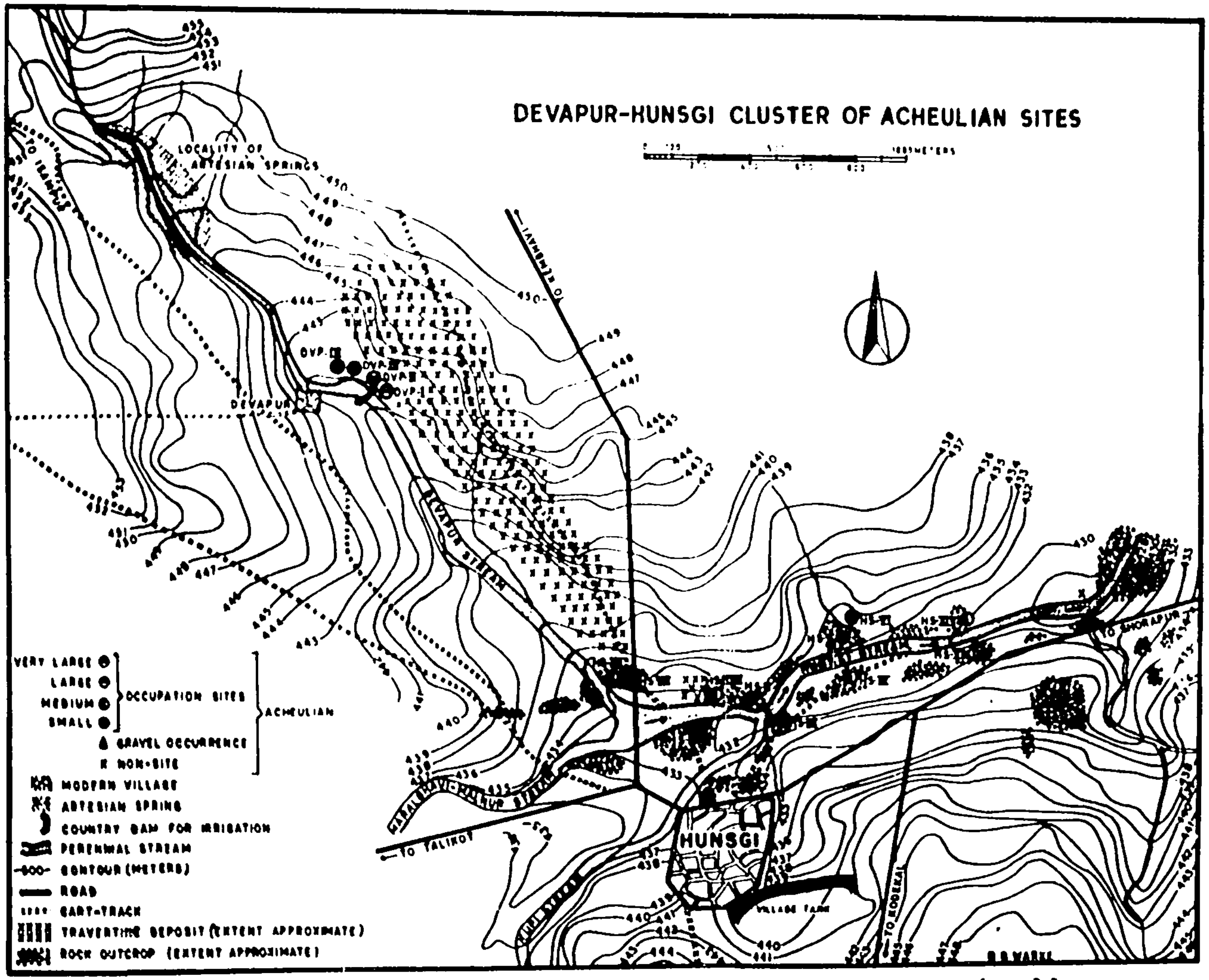


Fig. VIII 1. Hunsgi cluster of Acheulian sites (Paddayya, 1989).

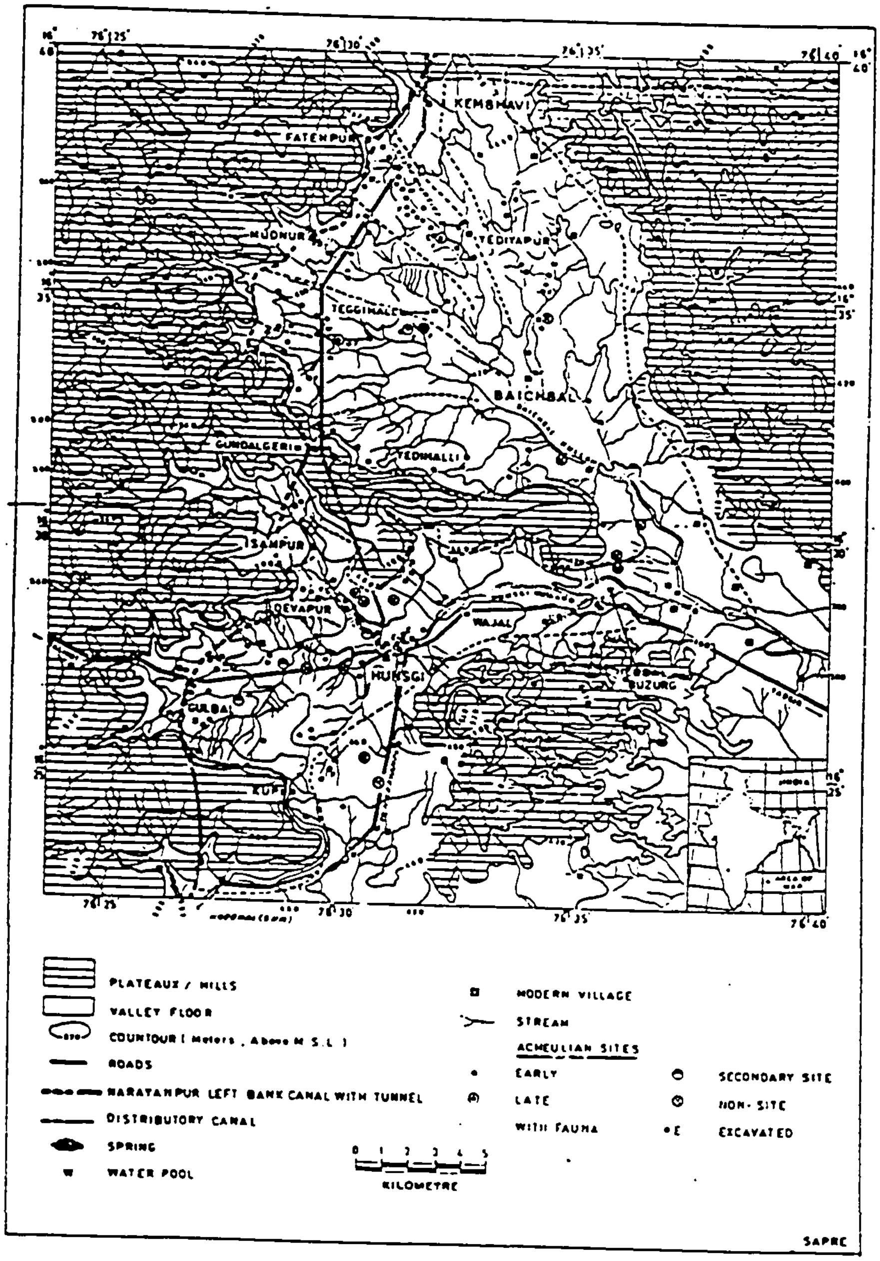


Fig. VIII 2. Map of the Hunsgi Valley showing the distribution of Acheulian sites in relation to topography, raw material, and water resources (Paddayya, 1989).





Fig. VIII 3. View from the valley floor to the limestone plateau.





Fig. VIII 4. Minor streams in the Hunsgi Valley (above), Hunsgi Nullah (below).

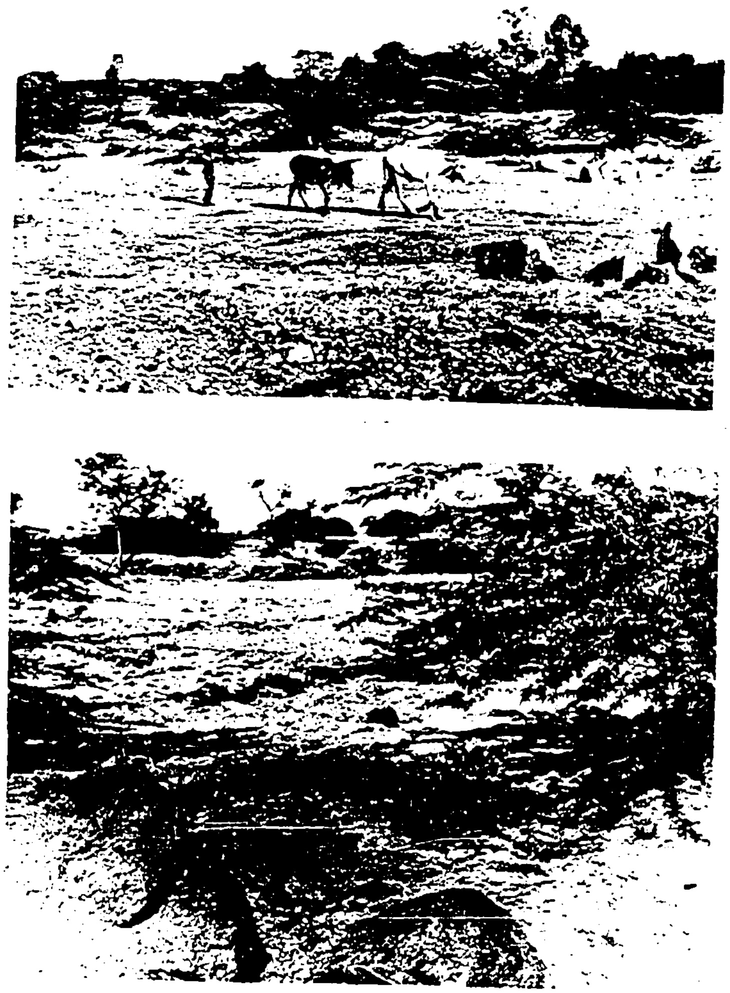


Fig. VIII 5. Geological features of Locality V at present.

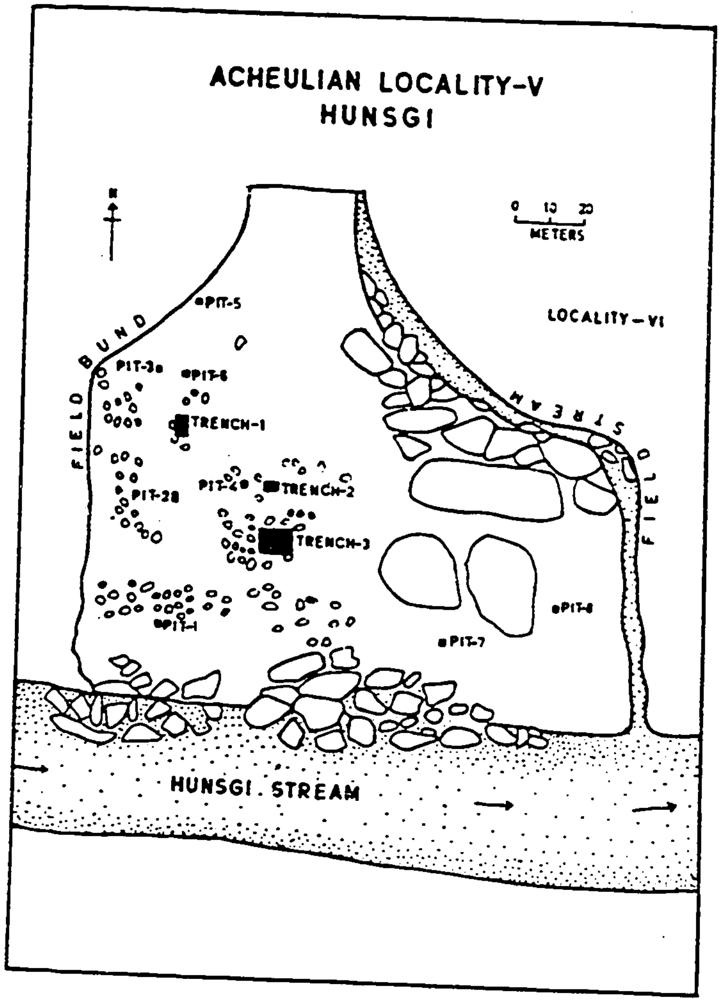


Fig. VIII 6. Map of Locality V at Hunsgi (Paddayya, 1982: Fig. 4).

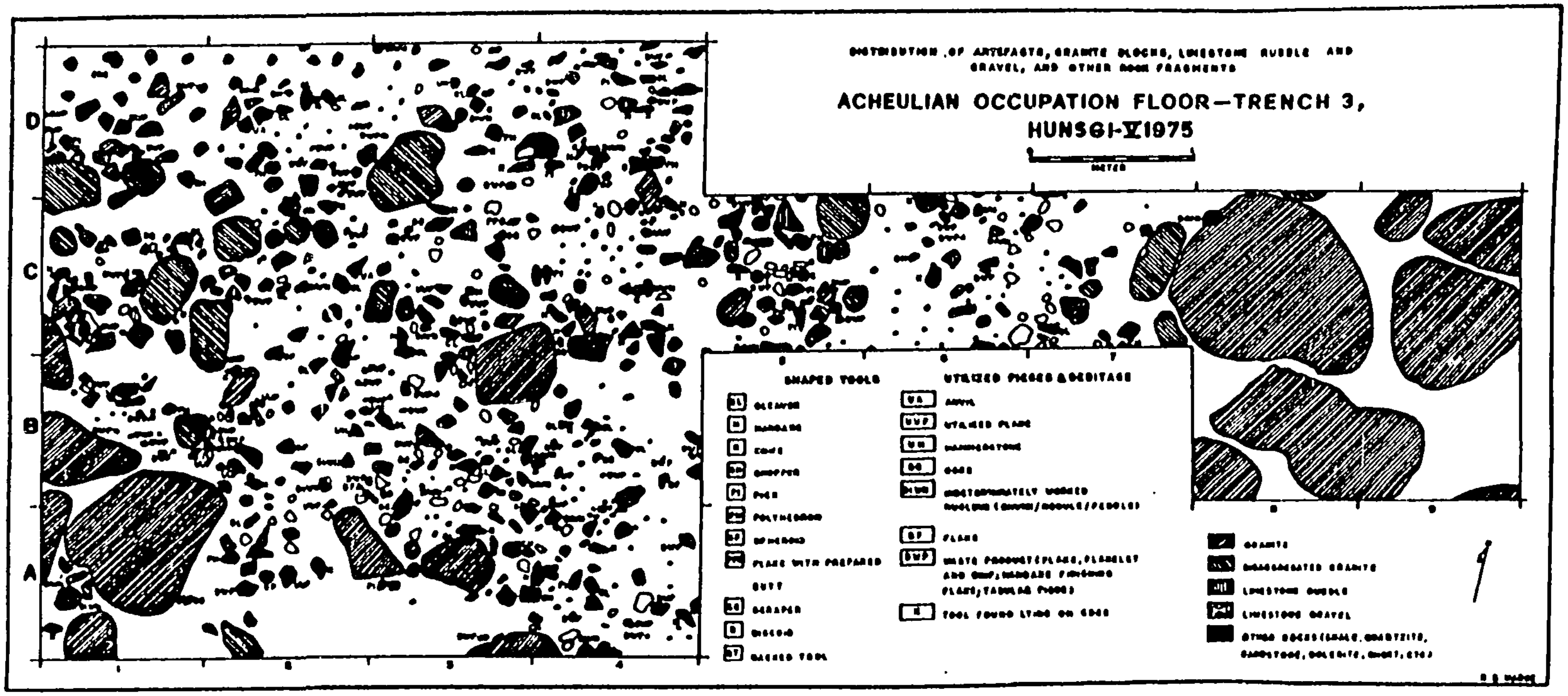


Fig. VIII 7. Distribution of artifacts, granite boulders, limestone rubble and gravel, and other rock fragments of the Acheulian occupation floor exposed in Trench 3 at Locality V, Hunsgi (Paddayya 1977b: Fig. 5).

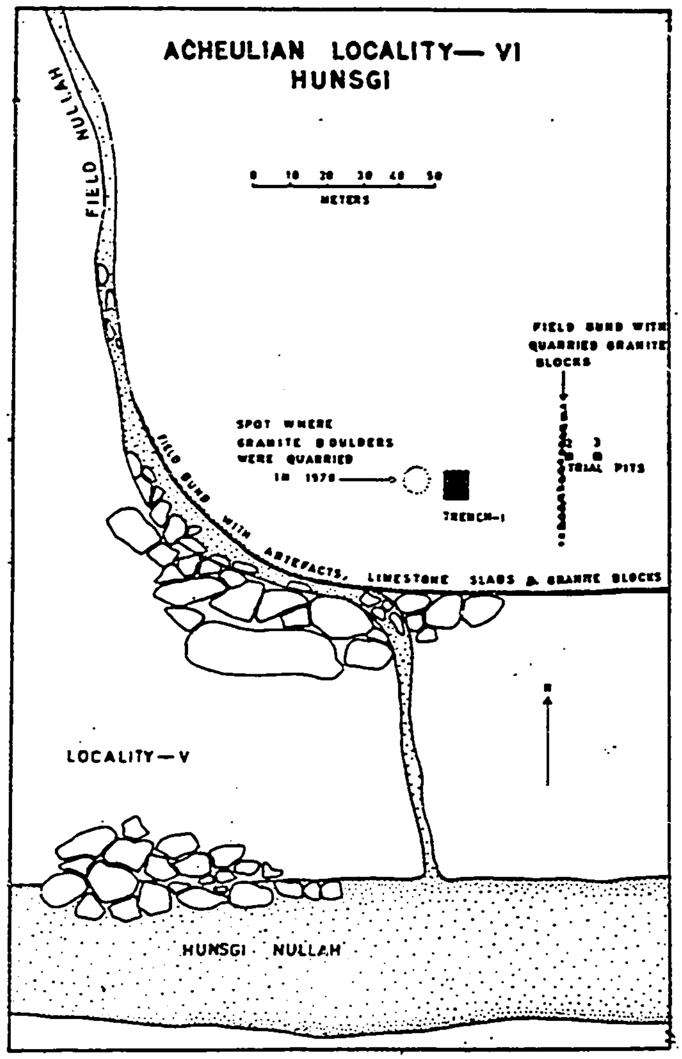


Fig. VIII 8. Map of Locality VI at Hunsgi (Paddayya, 1982: Fig. 8).

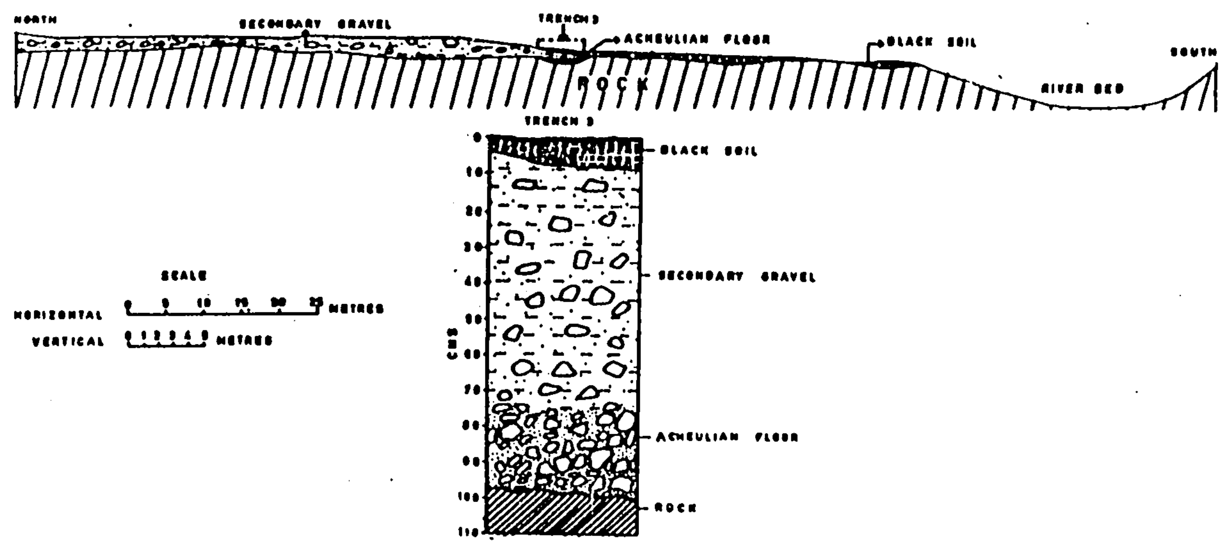


Fig. VIII 9. Transverse section at Locality V, Hunsgi, showing the stratigraphical position of the Acheulian occupation floor in relation to other deposits and the Hunsgi stream (Paddayya, 1977a: Fig. 13).

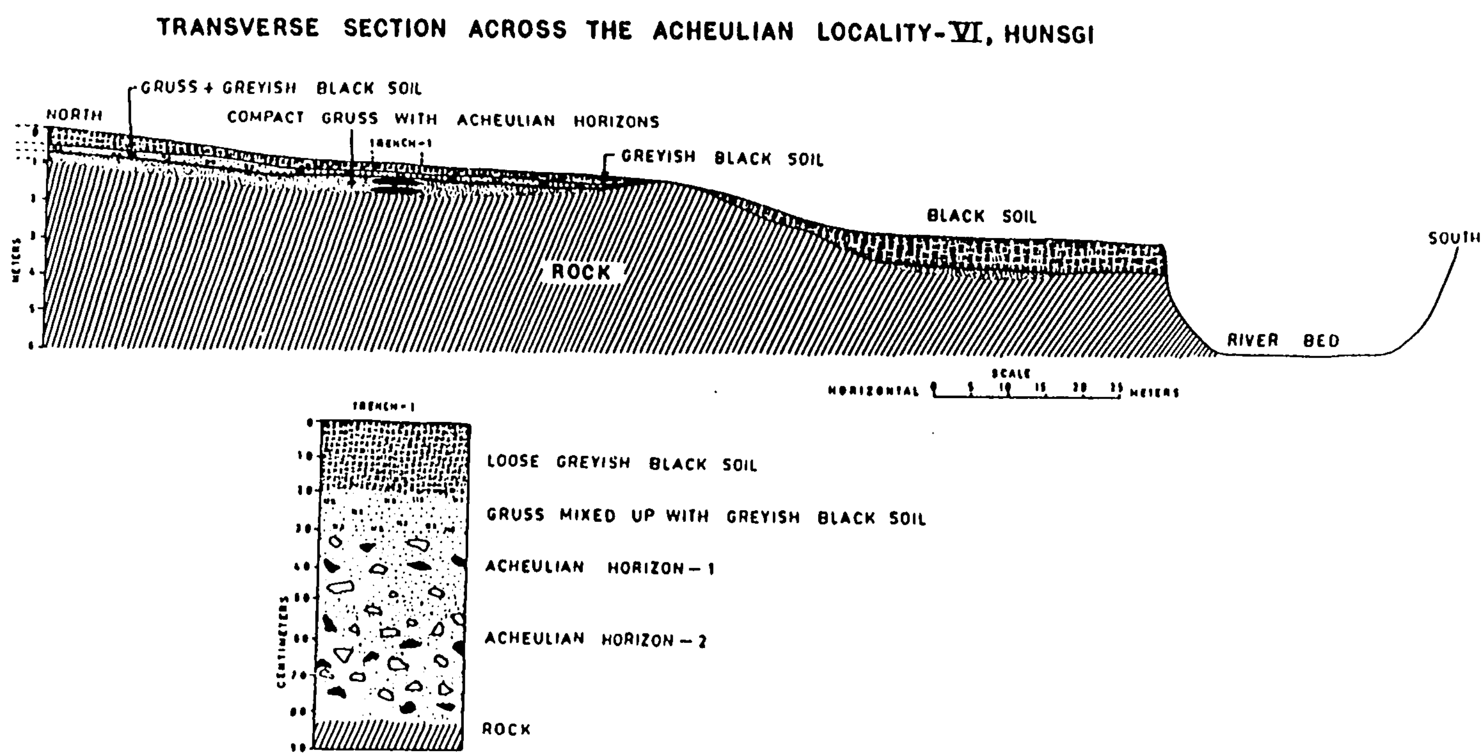


Fig. VIII 10. Transverse section at Locality VI, Hunsgi, showing the stratigraphical position of the Acheulian levels in relation to other deposits and the Hunsgi stream (Paddayya, 1982: Fig. 9).

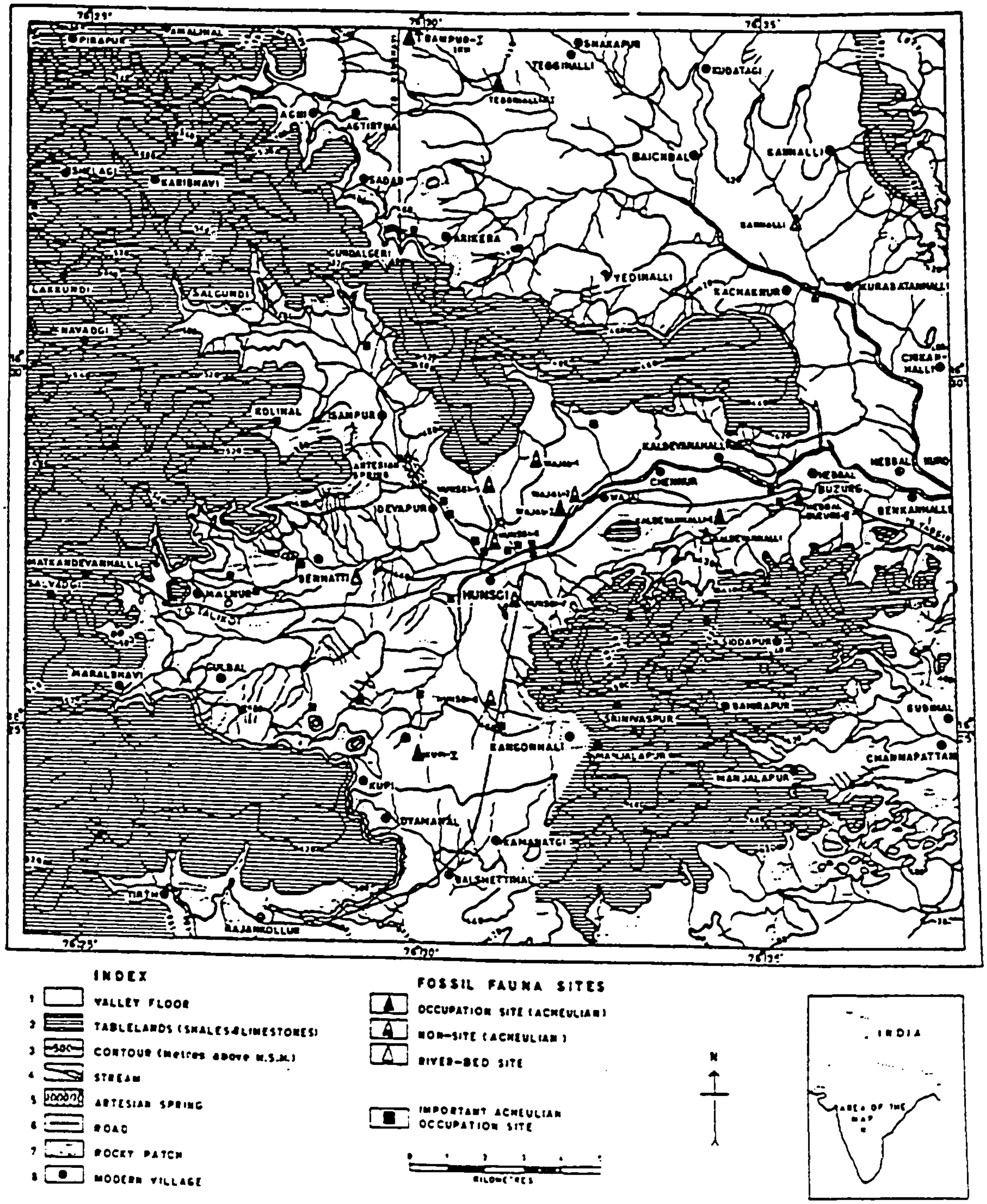


Fig. VIII 11. Map of the Hunsgi-Baichbal valleys showing fossil fauna sites in relation to Acheulian sites (Paddayya, 1985: Fig. 1).

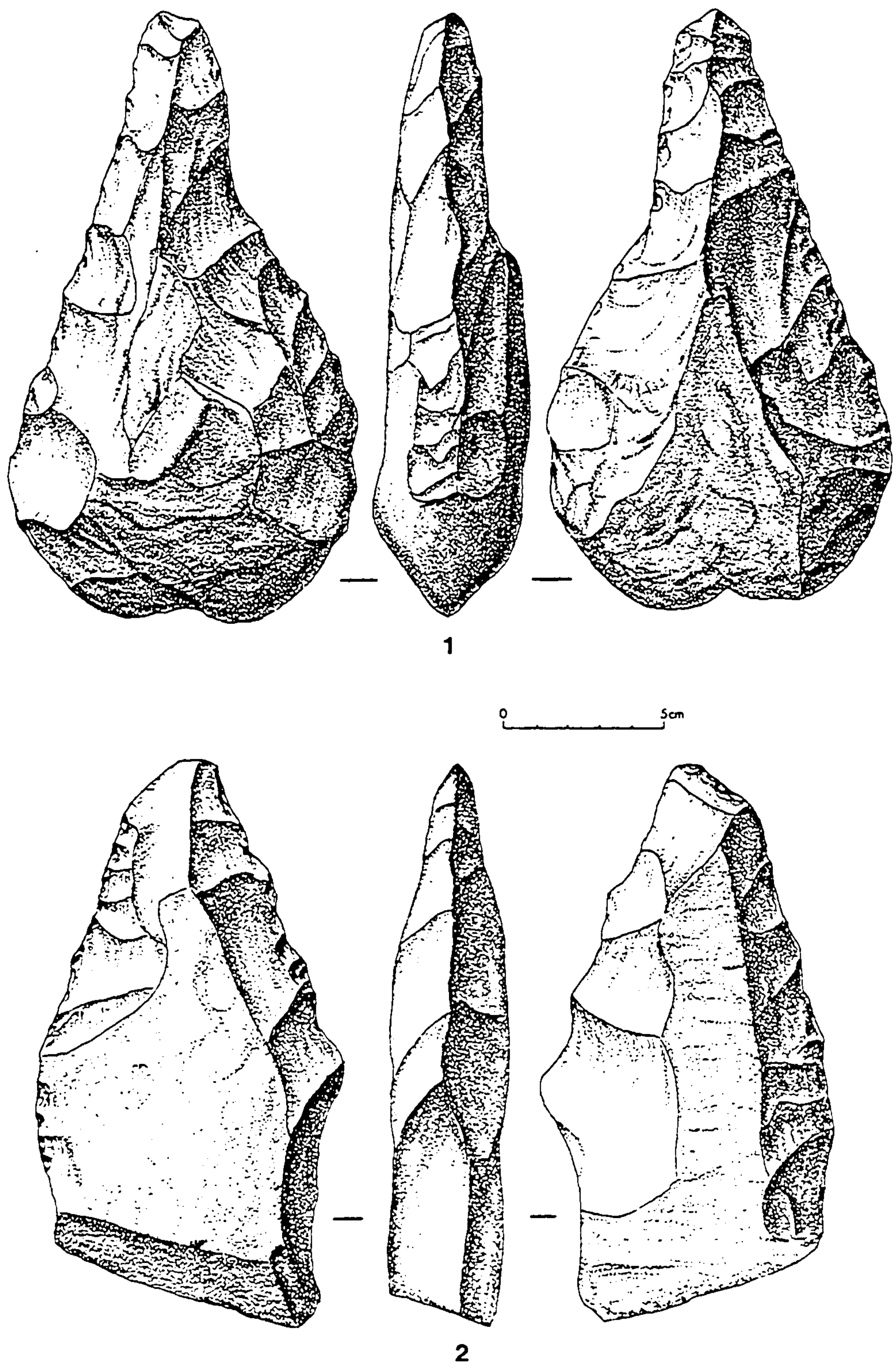


Fig. VIII 12. Tools of type C13 (1. Tr.3:45 2. Tr.3:34) from Hunsgi.

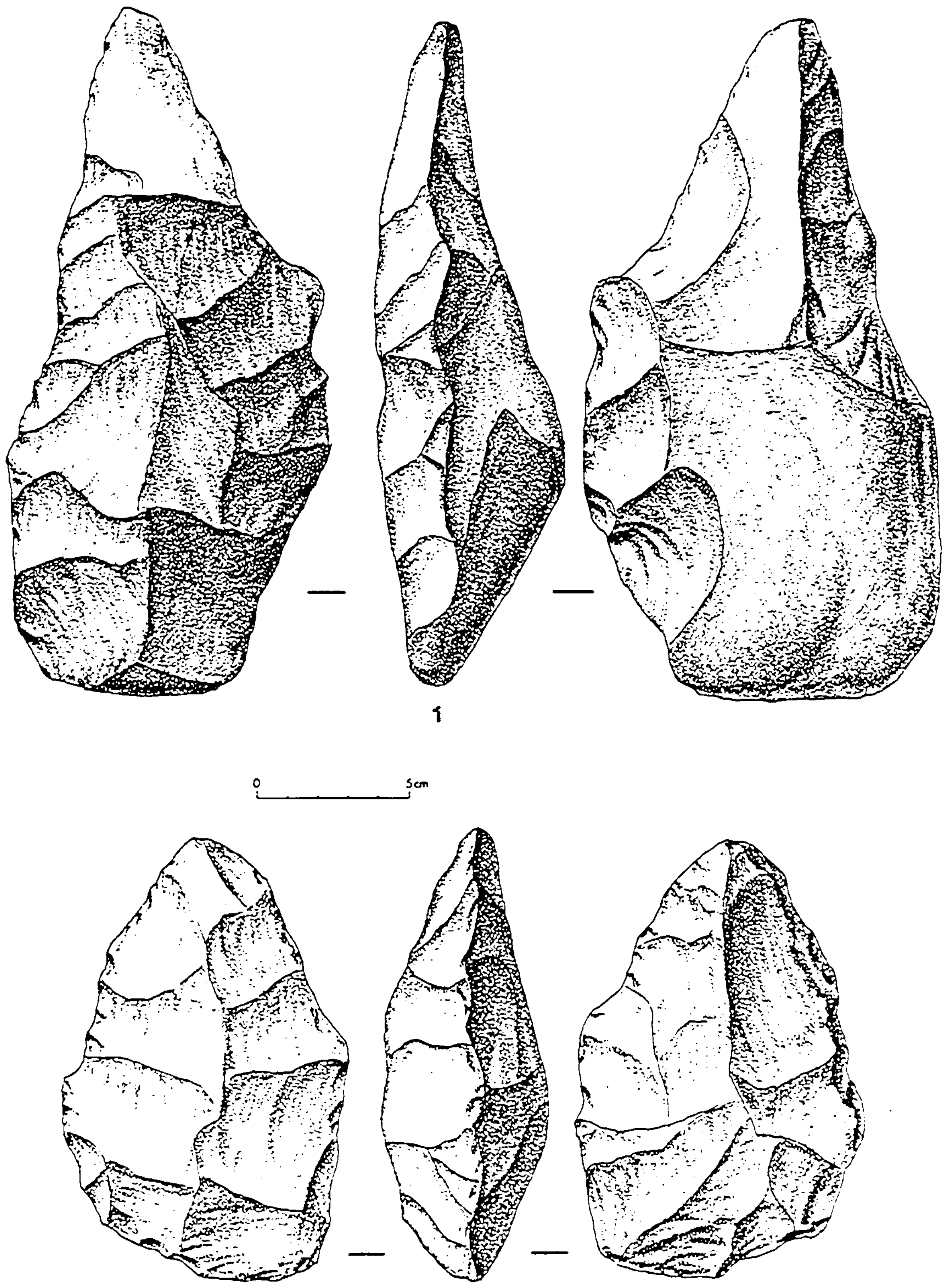


Fig. VIII 13. Tools of type C13 (1. Tr.3:35 2. Tr.3:32) from Hunsgi.

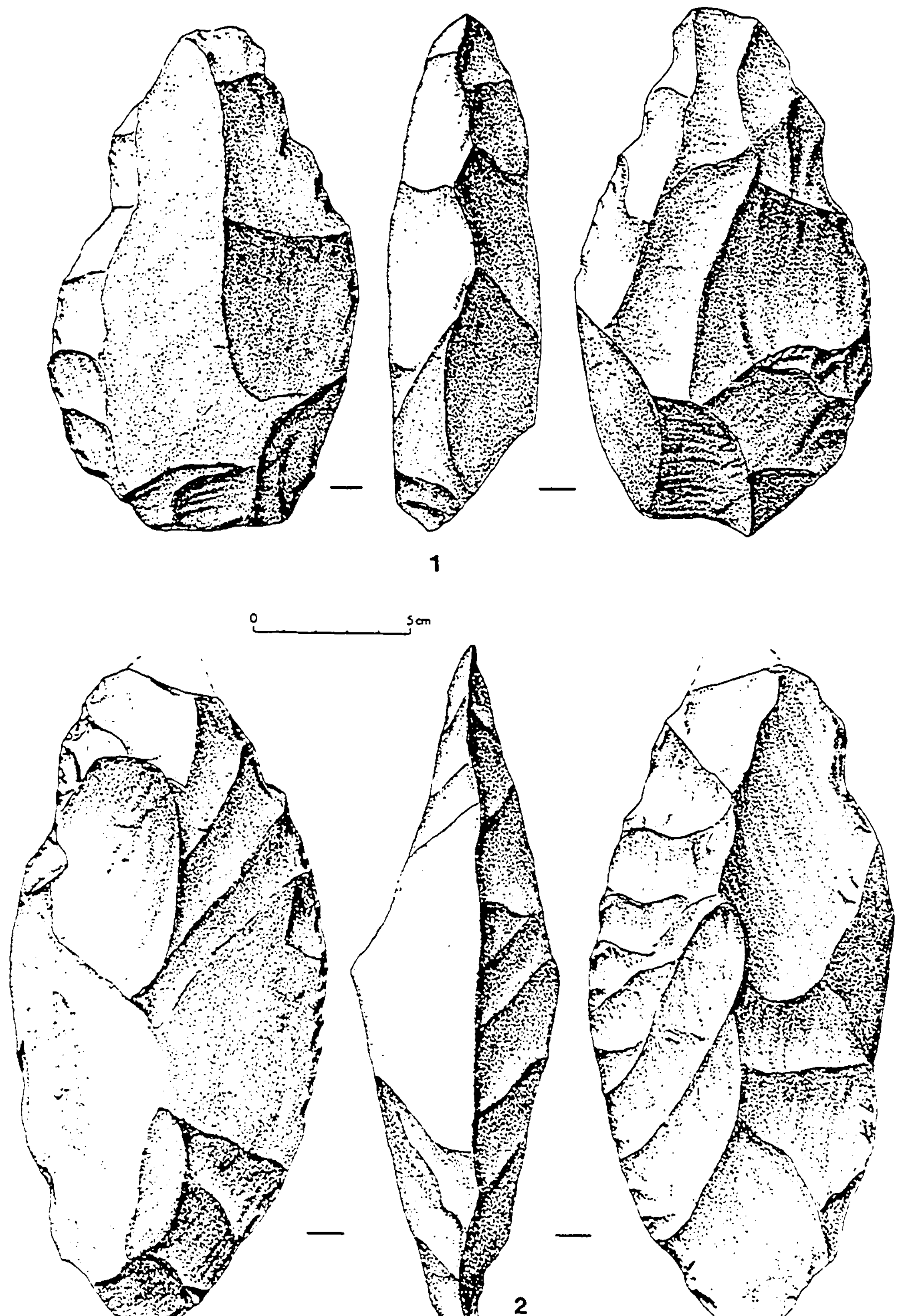


Fig. VIII 14. Tools of type C13 (1. Tr.1:17) and C14 (Tr.3:29) from Hunsgi.

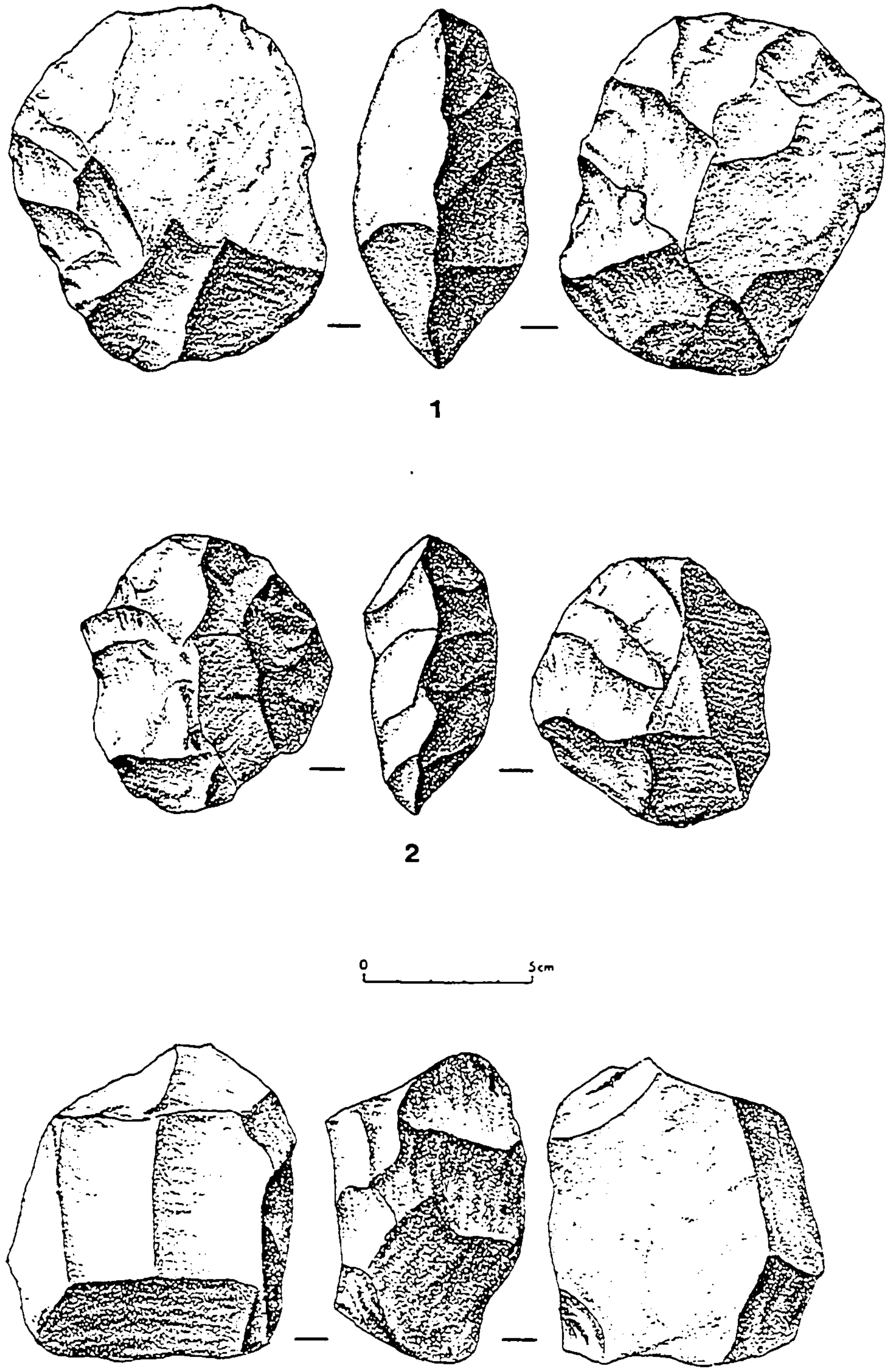


Fig. VIII 15. Tools of type C15 (1. Tr.3:42 2. Tr.3:108) and C17 (3. Tr.3:83) from Hunsgi.

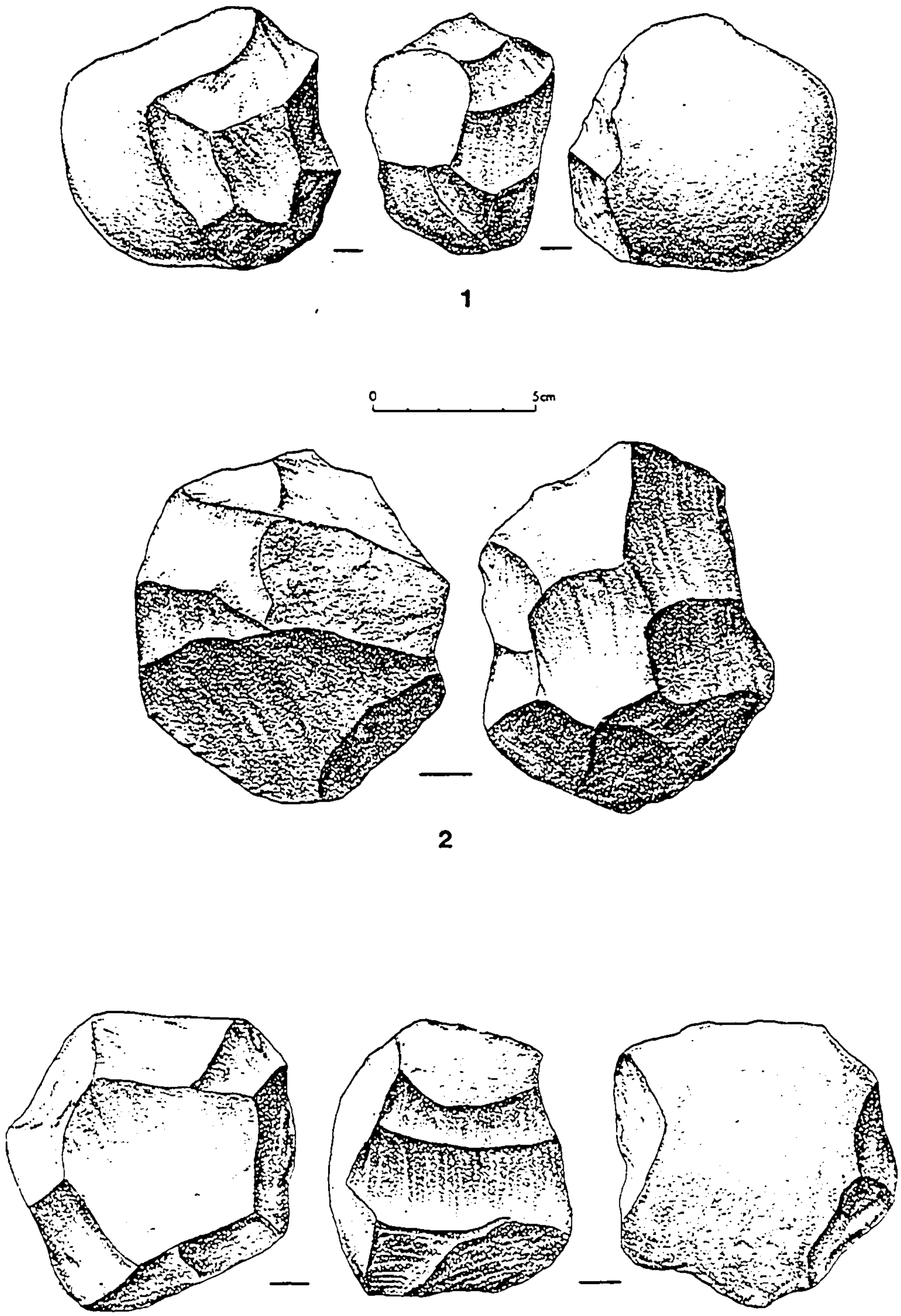


Fig. VIII 16. Tools of type C17 (1. Tr.1:262 2. Tr.3:77 3. Tr.1:3) from Hunsgi.

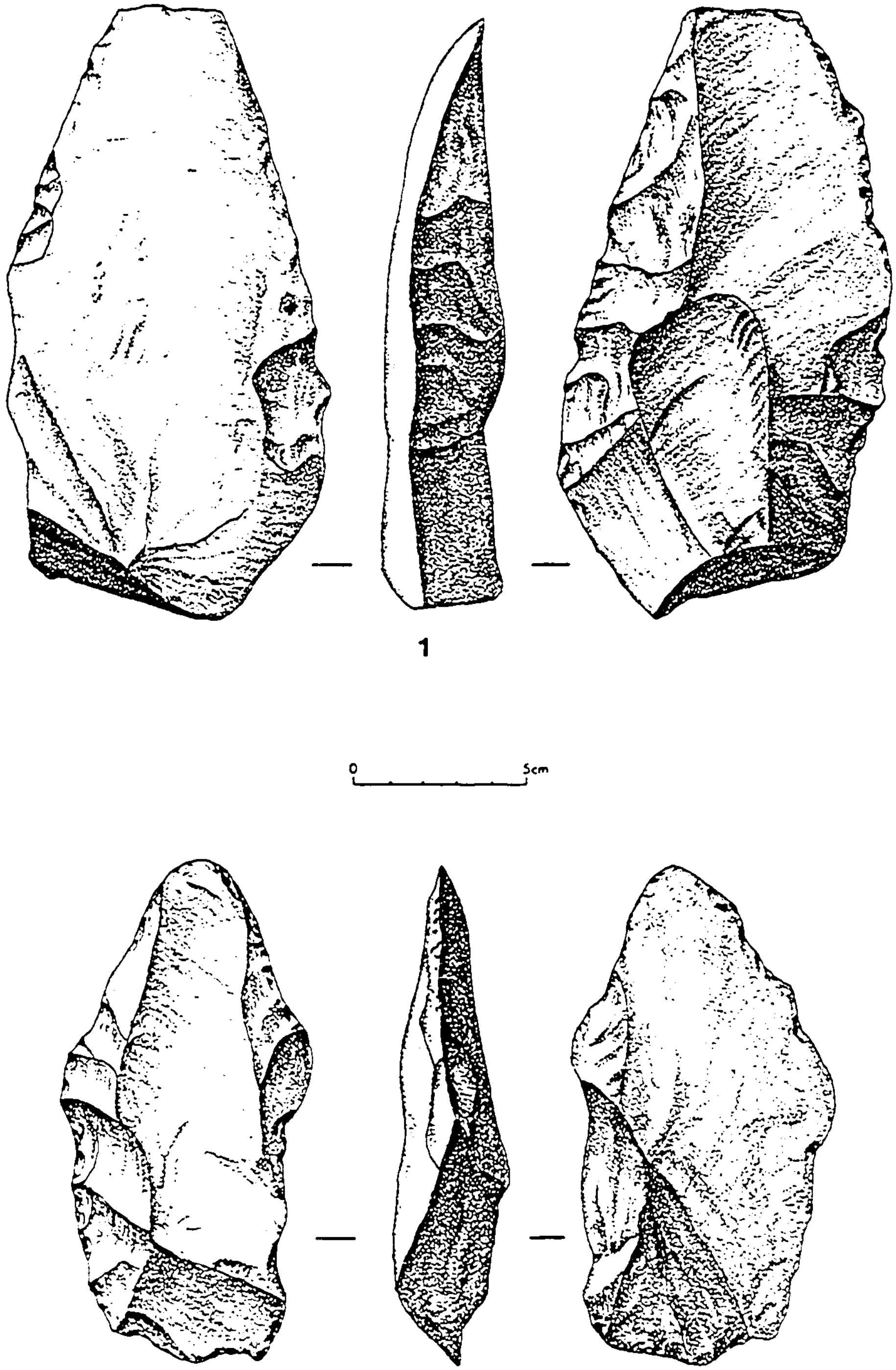


Fig. VIII 17. Tools of type F2 (1. Tr.3:52 2. Tr.3:56) from Hunsgi.

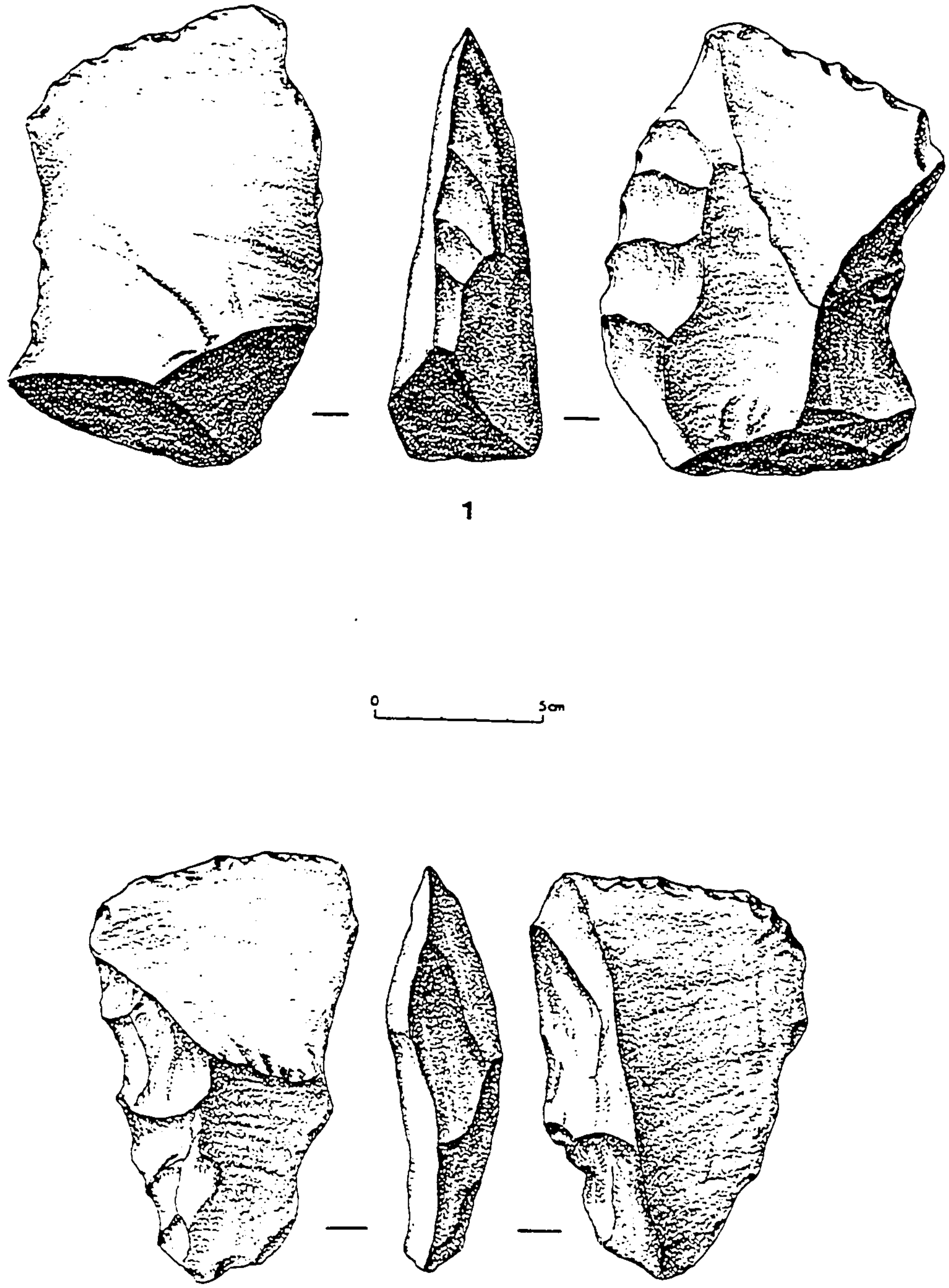


Fig. VIII 18. Tools of type F2 (1. Tr.3:28 2. Tr.3:24) from Hunsgi.

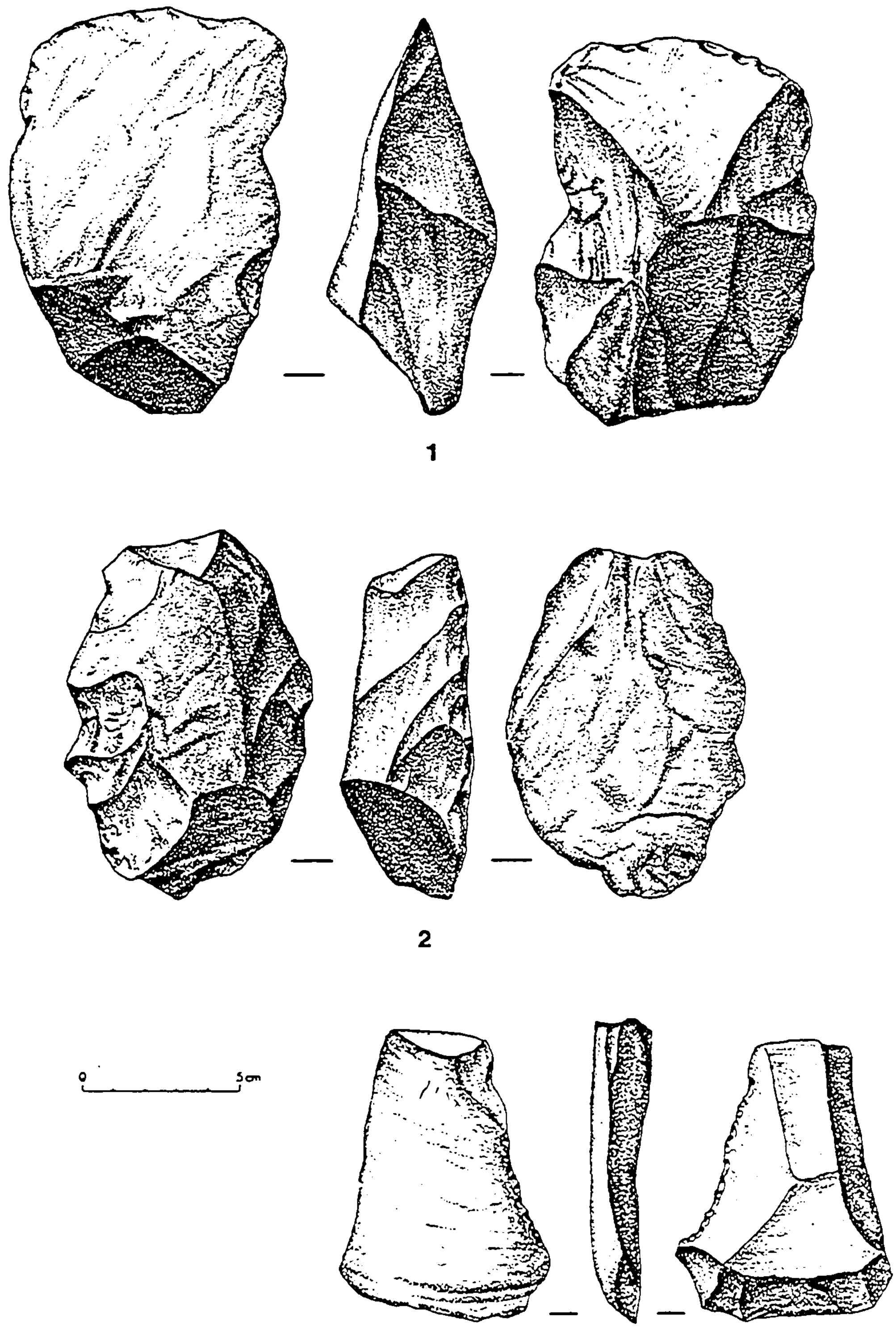


Fig. VIII 19. Tools of type F2 (1. Tr.3:20), F10 (2. Tr.3:127) and F7 (3. Tr.3:271) from Hunsgi.

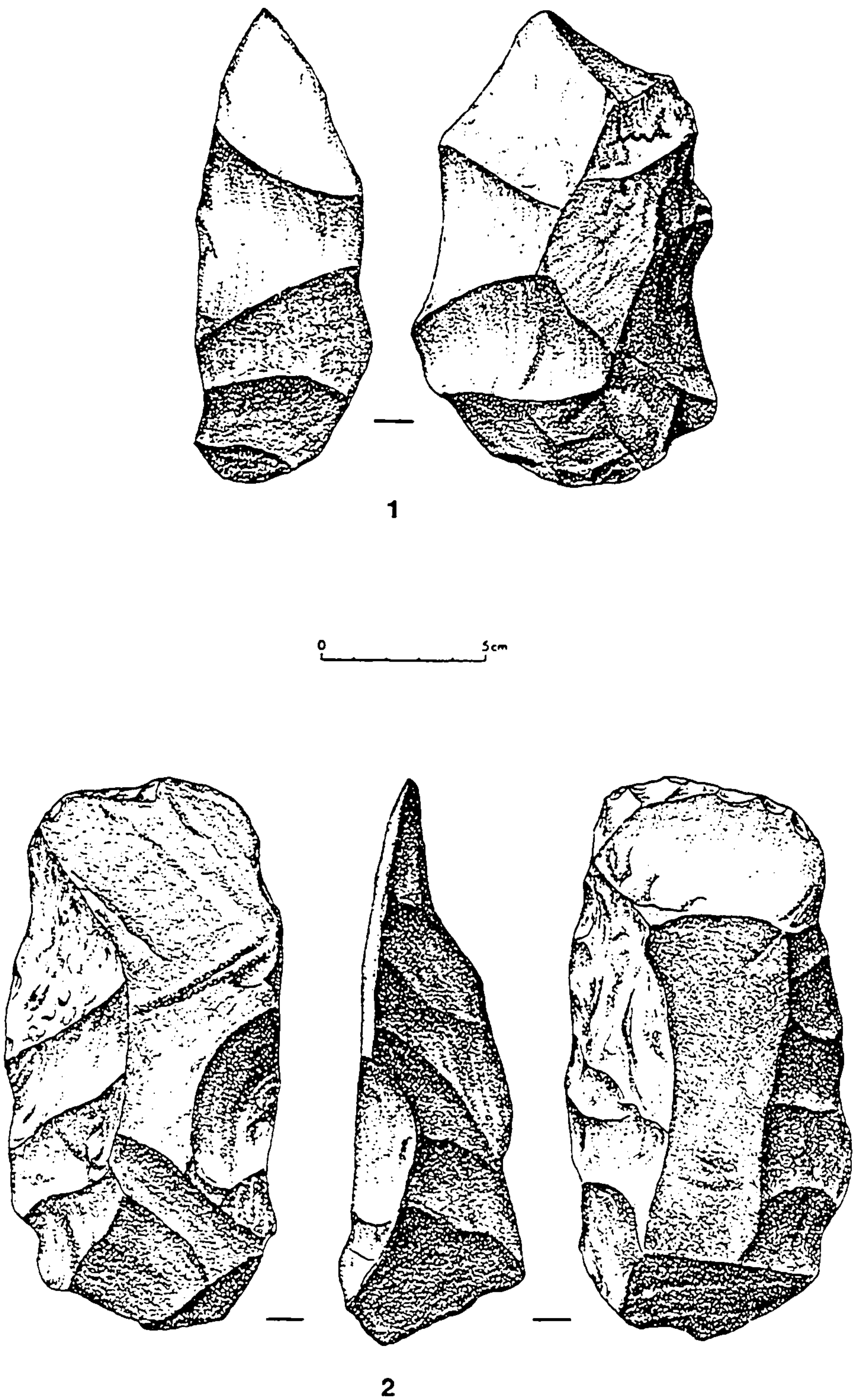


Fig. VIII 20. Tools of type F10 (1. Tr.3:36) and F13 (2. Tr.3:27) from Hunsgi.

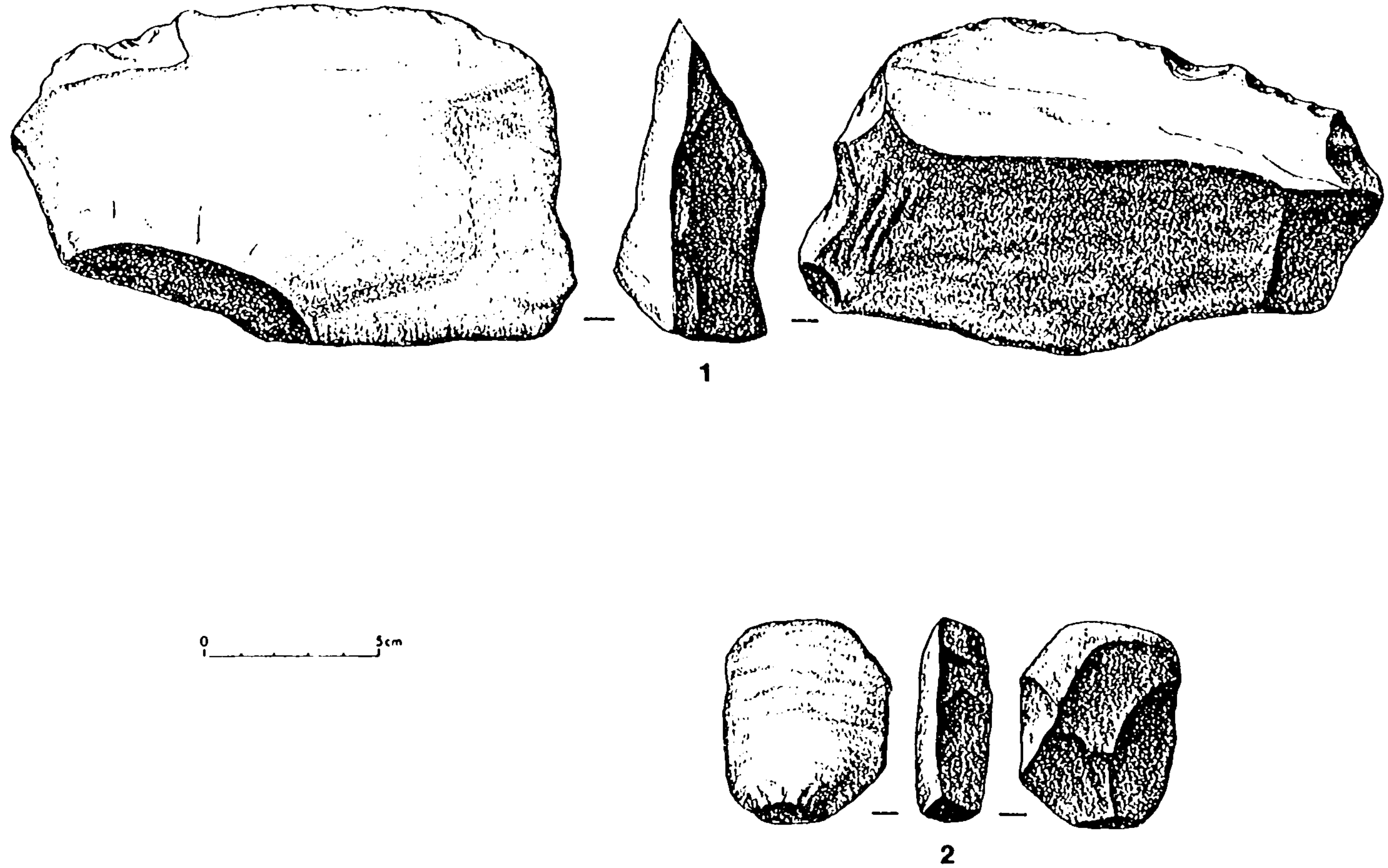


Fig. VIII 21. Tools of type U1 (1. Tr.3:53) and D1
(2. Tr.3:272) from Hunsgi.





Fig. VIII 22. Cobbles and chunks of limestone or granite on the Hunsgi valley floor.



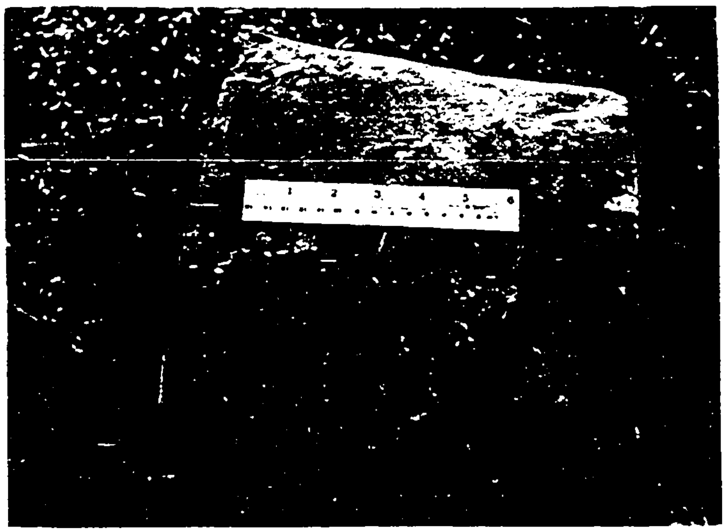


Fig. VIII 23. Hunsgi valley floor (Pictured is Mr. Basappa who guided me around the valley in 1989).





Fig. VIII 24. Limestone blocks or slabs on Hunsgi valley floor (above), a local farmer working on the limestone materials (below).



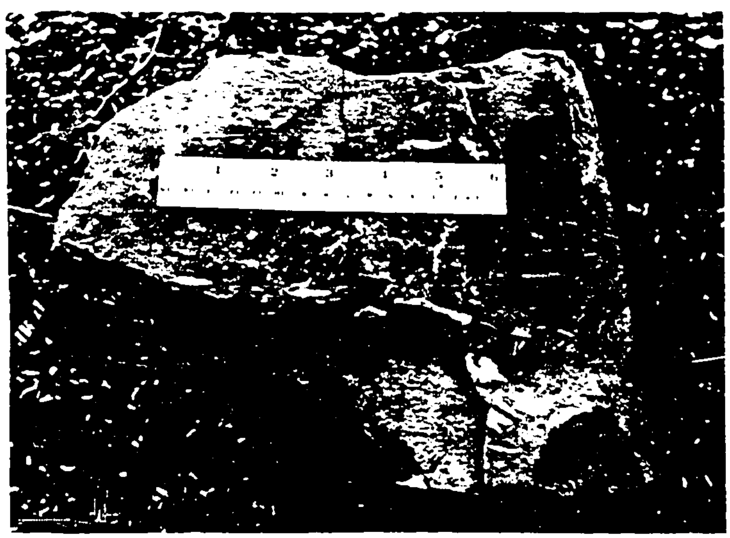


Fig. VIII 25. Limestone blocks and slabs used in the replicative studies at Hunsgi site.



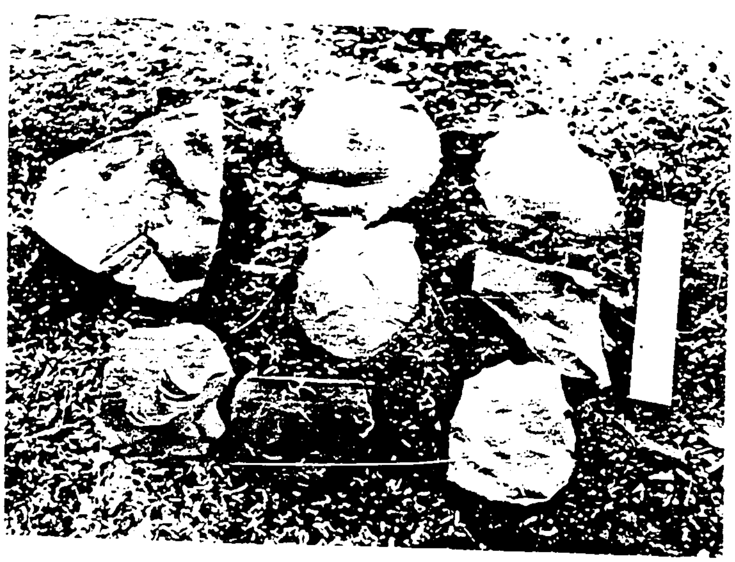


Fig. VIII 26. Hammerstones used in the replicative studies at Hunsgi site (above), replication: 8 large flakes (below).

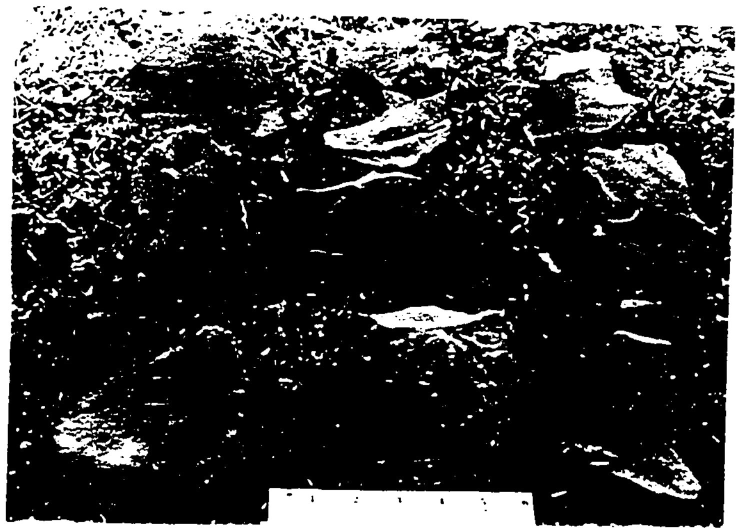




Fig. VIII 27. Replication: flakes from roughing out step at Hunsgi site (above), flakes and debitage from trimming 1 limestone slab (below).

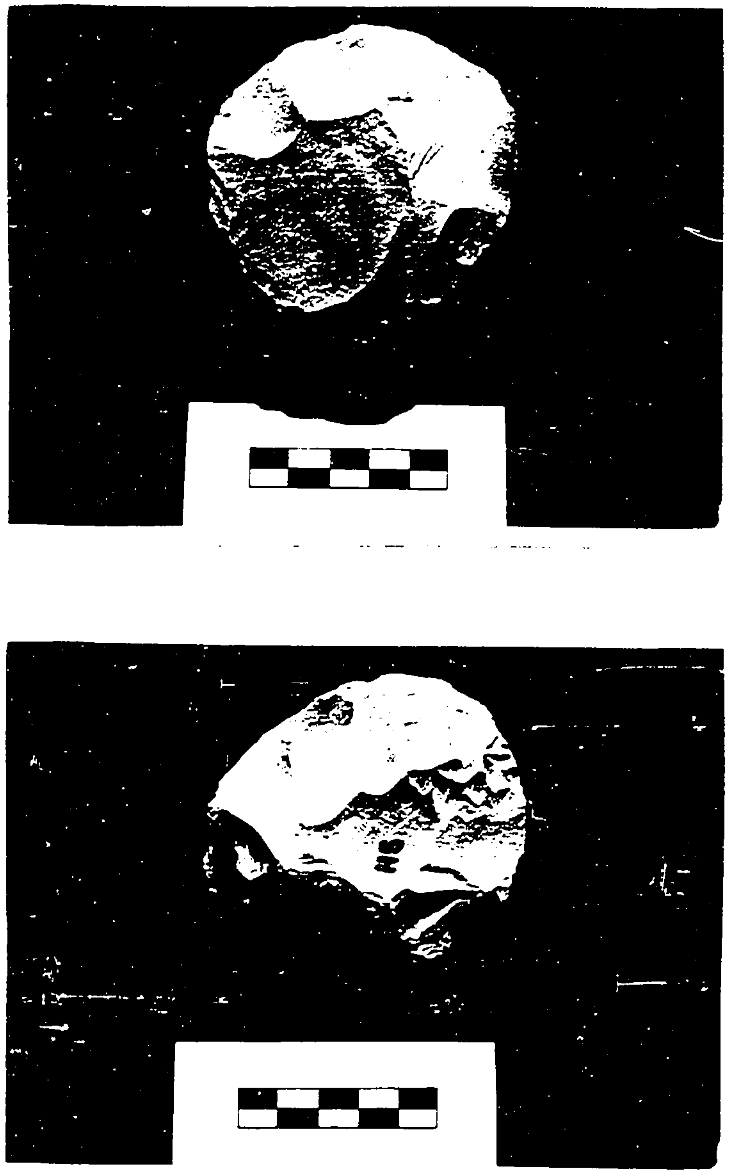


Fig. VIII 28. Replication: C15, of Hunsgi.

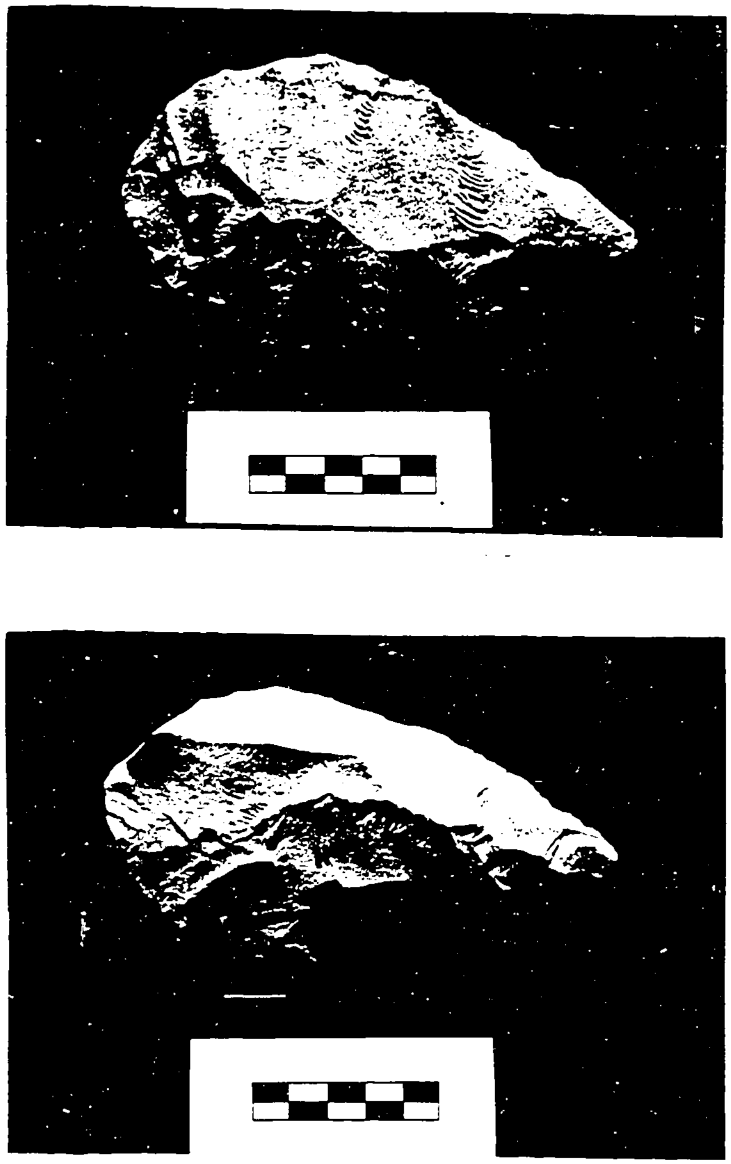


Fig. VIII 29. Replication: C13, of Hunsgi.

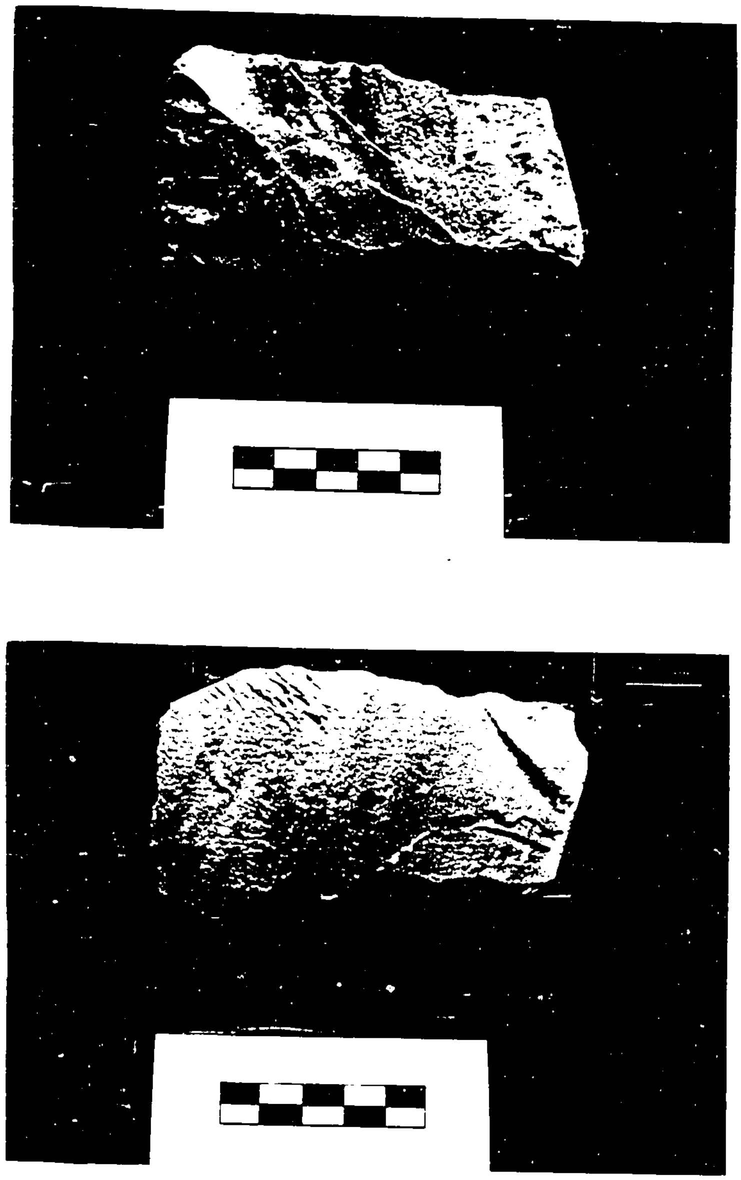


Fig. VIII 30. Replication: F7, of Hunsgi.



Fig. VIII 31. Replication: F14, of Hunsgi.

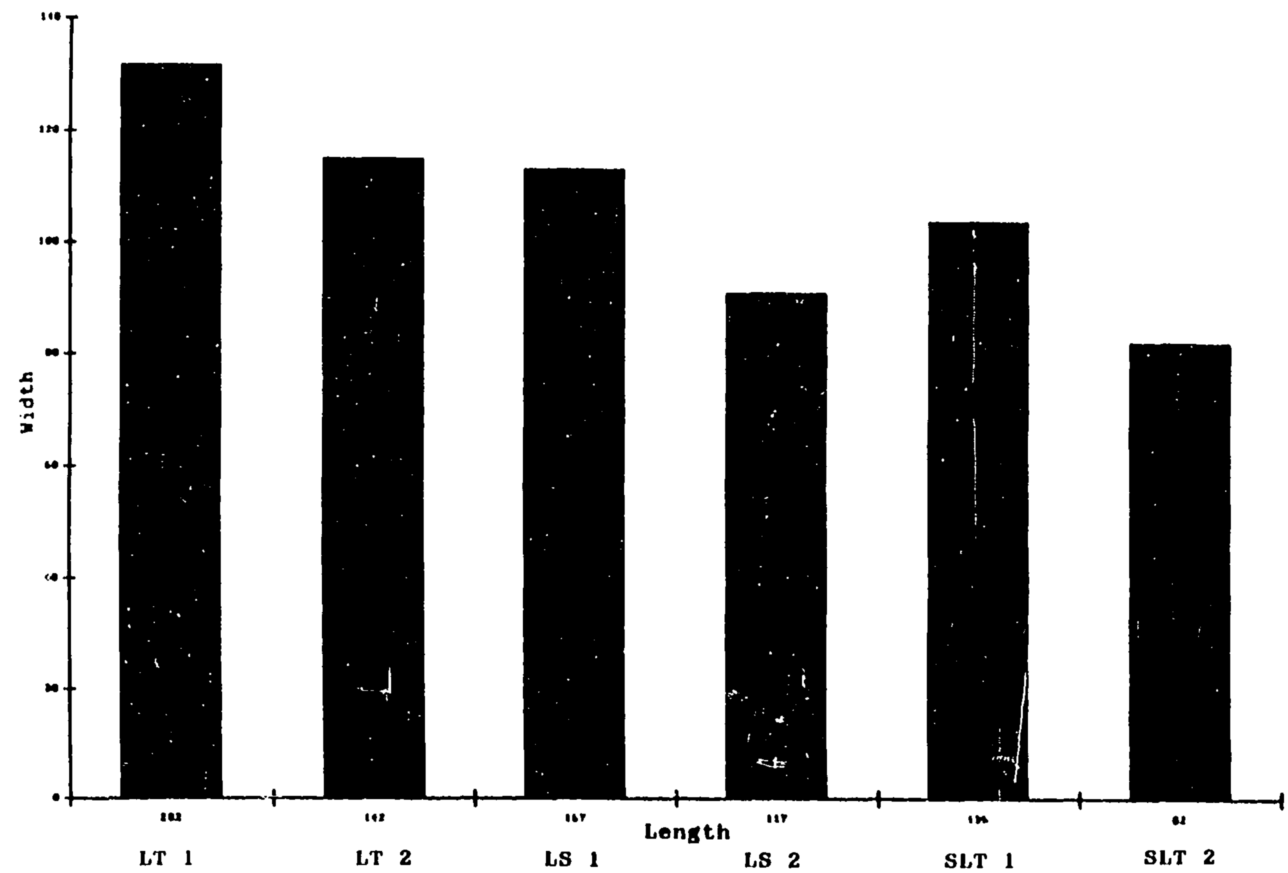


Fig. 1. The size (length x width) of primary quartzite raw materials and core tools. Key: 1. Primary raw materials 2. Core tools LT = Lantian LS = Liangshan SLT = Shilongtou

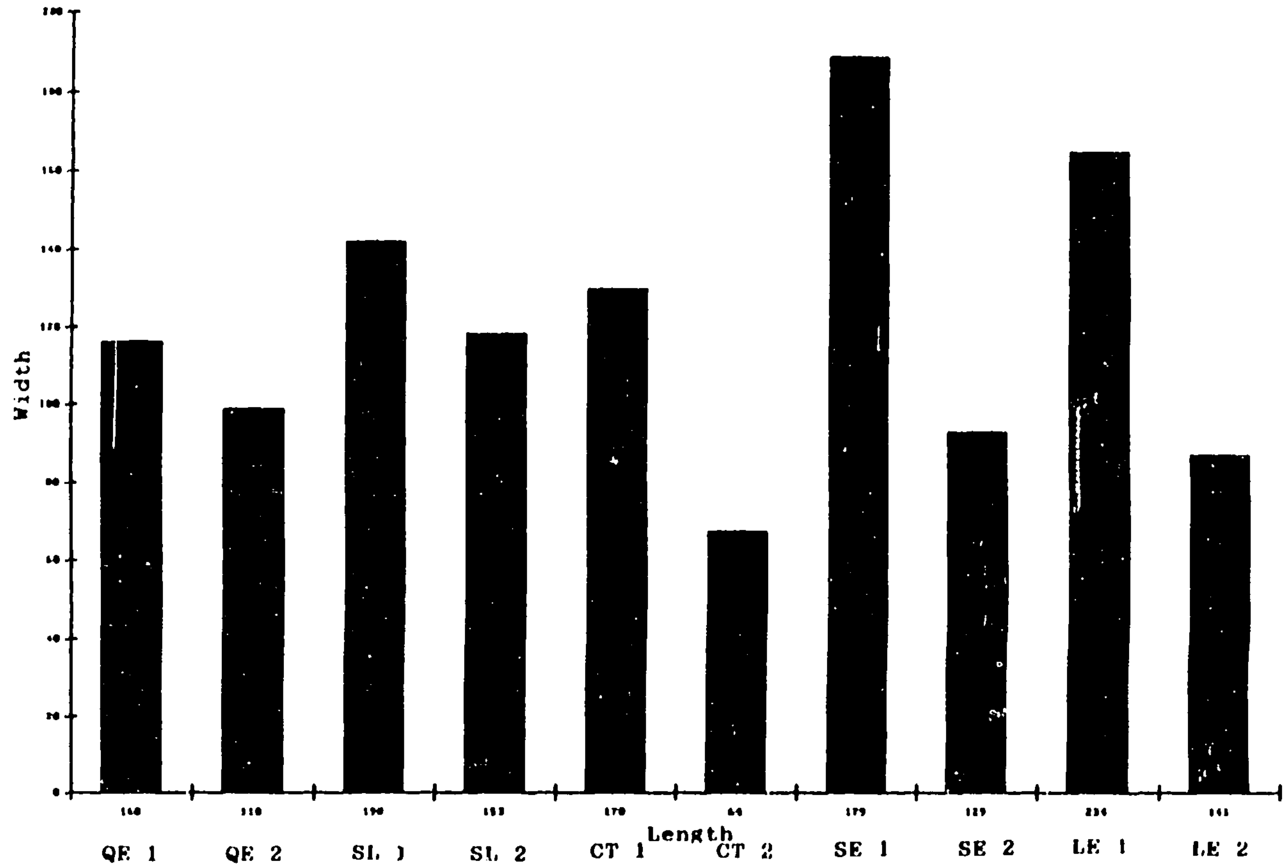


Fig. 2. The sizes (length x width) of primary raw materials and core tools. Key: 1. Primary raw materials 2. Core tools
QE = Quartzite SL = Silicified limestone CT = Chert
SE = Sandstone LE = Limestone

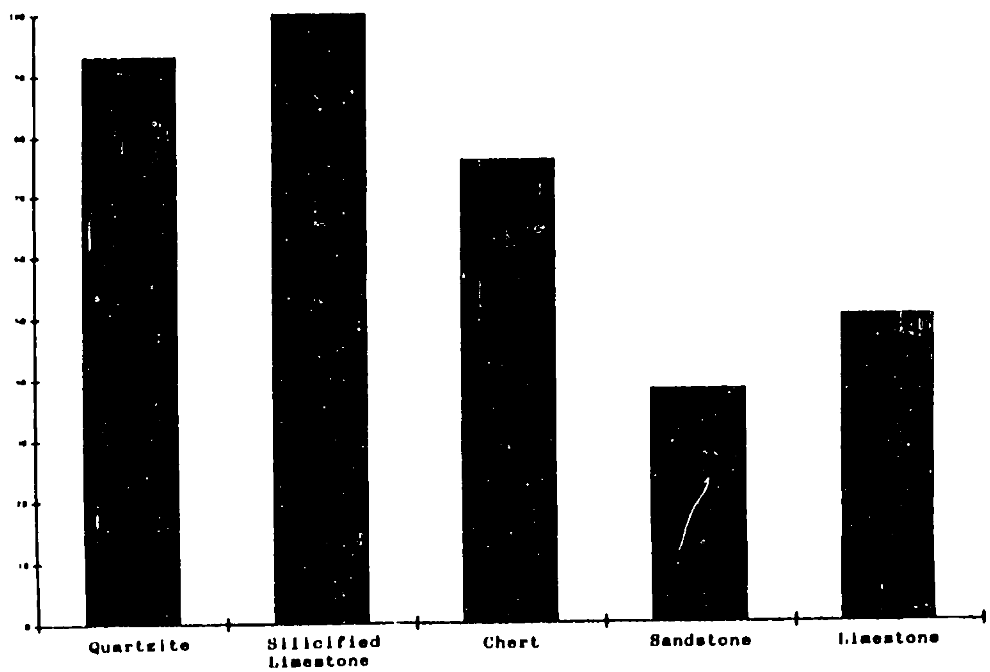


Fig. 3. Percentage of specimens with cortex remaining on five different raw materials.

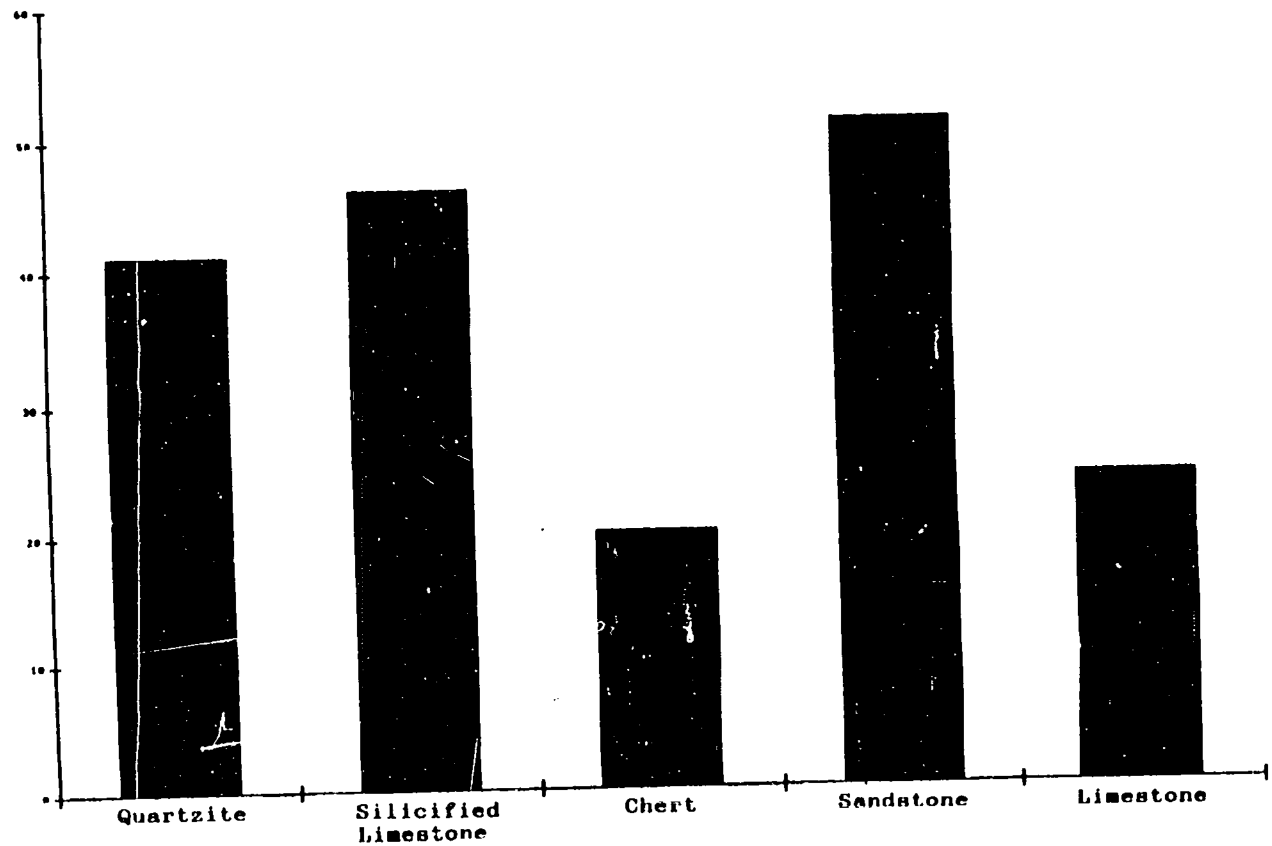


Fig. 4. The average percentage of cortex on each specimen of five different raw materials.

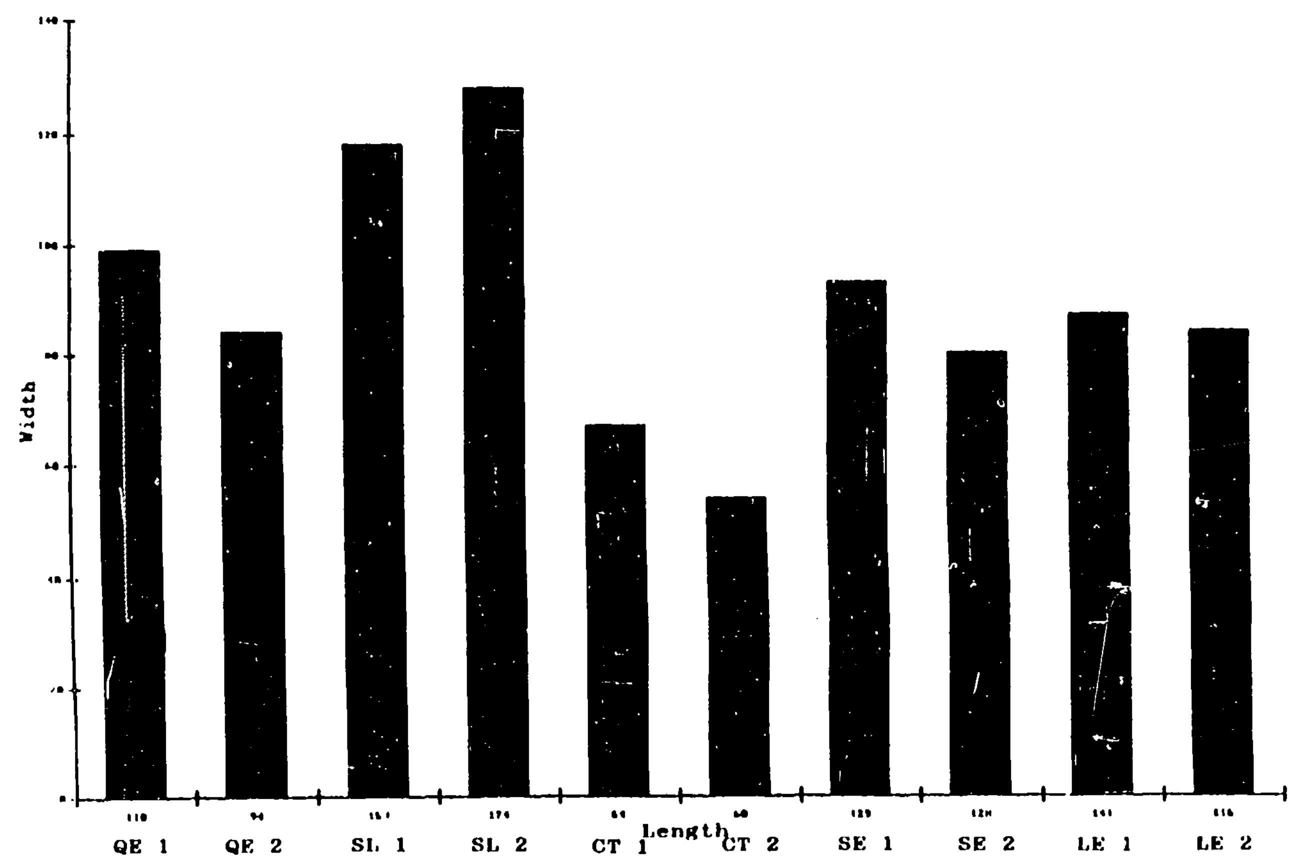


Fig. 5. The sizes of cores and flake specimens for five different raw materials. Key: 1. Core tools 2. Flake tools
QE = Quartzite SL = Silicified limestone CT = Chert
SE = Sandstone LE = Limestone